“A new spatial basis for rivers monitoring and management in Cyprus”

A project submitted to Middlesex University in partial fulfilment of the requirements for the degree of Doctor of Professional Studies

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„Alle diese Flüsse und Bäche der Insel führen ohne Ausnahme im Sommer kein Wasser in ihren unteren Theilen, und selbst näher ihrem Ursprünge ist ihre Wassermenge nur sehr gering…“

[All these rivers and streams of the island, without exception, do not carry water in summer in their lower reaches and, even near their origins, is their amount of water low ...]

(Unger and Kotschy, 1865, p.4)

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ABSTRACT

Shortcomings of river typology, river water body network and water body assessment grouping were identified to impede the Water Framework Directive's (WFD) implementation in Cyprus. A new spatial basis for river monitoring and management was elaborated to alleviate these problems.

A stream definition threshold determined from topographical maps and a 20x20m DEM were used for the stream definition process. Consistent quantitative and WFD compliant criteria were applied to identify the new WFD stream network. A new river typology based on the Temporary Stream Regimes of Gallart et al. (2012) was elaborated and comprises four types covering the entire flow permanence gradient (perennial – intermittent - ephemeral/episodic). The applicability of biological monitoring for WFD purposes is exactly specified for each type. For mapping the types onto the stream network, a tiered approach allowed employing the most reliable stream type predictor for each river reach. For ungauged stream reaches, relationships between stream types and catchment characteristics were established and a multi-criteria methodology for assigning types to reaches was developed and applied. The resulting stream network comprises 14% perennial and 86% temporary stream reaches. It represents the first mapping of temporary flow regimes onto a Cyprus-wide river network. Subsequently, water bodies were delineated considering location and spatial extent of pressures, differences in water status and protected areas. Monitoring sites' ecological status was related to pressures, and thresholds for three pressure levels (negligible, minor, significant) were determined and used to develop an indicator allowing the prediction of pressure levels and related ecological status in water bodies.

The new scheme is already being utilized for the elaboration of the second Cyprus River Basin Management Plan.

In parallel to the elaboration of the new scheme, anticipated benefits and potential negative effects of the new scheme's adoption were collected through a stakeholder consultation process, carried out in two action research loops with a total of five consultation sessions. The stakeholders present in the sessions included all significantly involved Government Departments, a contractor and, in the last session, environmental organizations, local Authorities and the general public. Identified benefits are few but significant and refer to improved monitoring, the benefits of the new typology, identified gaps and the developed re-usable methodologies.

Identified causes for potential negative effects of an adoption of the technical proposal, anticipated mainly in the form of opposition of the European Commission, are the treatment

of HMWBs in the assessment groups scheme, the compatibility of the new types with the results of the intercalibration exercise and the fact that the river network is completely new, in comparison to the first RBMP. All these do not bear but small or minimal chances to entail negative effects in practice.

Differing views amongst stakeholders about several areas of WFD implementation were also identified. They exist between the stakeholders but also within Governmental Departments and refer e.g. to the “ideal” density of the stream network and the treatment of ephemeral/episodic rivers under the WFD.

Glossary

The glossary is based on definitions given in WMO and UNESCO (2012), NOAA (n.d.), Hubert et al. (n.d.) and in the Water Framework Directive (European Parliament and European Council, 2000)

Catchment	Area having a common outlet for its surface runoff. *Syn*. catchment area; drainage area; river basin; watershed
Downstream	In the direction of the current in a river or stream. *Abbr.:* d/s
Ecological status	An expression of the quality of the structure and functioning of aquatic ecosystems associated with surface waters, classified in accordance with Annex V of the WFD.
Flow gauging station	Location on a stream where measurements of water level and discharge are regularly made
Flow regime	The seasonal distribution of one or more hydrological elements at a particular location
Good ecological potential	The status of a heavily modified or an artificial body of water, so classified in accordance with the relevant provisions of Annex V of the WFD
Good ecological status	The status of a body of surface water, so classified in accordance with Annex V of the WFD
Headwaters	Streams at source of a river
Heavily modified water body	A body of surface water which as a result of physical alterations by human activity is substantially changed in character, as designated by the Member State in accordance with the provisions of Annex II of the WFD
Main stem	The reach of a river/stream formed by the tributaries that flow into it
Monitoring	Continuous or frequent standardized measurement and observation of the environment
Reach	The distance between two specific points outlining that portion of the stream, or river
River/stream mouth	Place of discharge of a river into a sea or a lake
River/stream network	Aggregate of rivers and other permanent or temporary water courses within an area
Stream	Body of water, generally flowing in a natural surface channel. *Syn*. river; watercourse
Stream flow	General term for water flowing in a stream or river channel
Subcatchment	A geographic area representing part of a catchment. *Syn*. subwatershed; subbasin
Surface water status	General expression of the status of a body of surface water, determined by the poorer of its ecological status and its chemical status
Upstream	In the direction towards the source of a stream. *Abbr.:* u/s
Water body, body of surface water’	A discrete and significant element of surface water such as a lake, a reservoir, a stream, river or canal, part of a stream, river or canal, a transitional water or a stretch of coastal water

Abbreviations

amsl	above mean sea level
AR	Action research
BQE	Biological Quality Element
CAP	Common Agricultural Policy (of the EU)
CIS	Common Implementation Strategy (of the Water Framework Directive)
COMM	European Commission
CPI	Combined pressure indicator
DEM	Digital Elevation Model
E.U.	European Union
ECOSTAT	Working Group on Ecological Status under the CIS
GEP	Good Ecological Potential
GIG	Geographical Intercalibration Group
GIS	Geographical Information System
IC	Intercalibration
IHA	Indicators of Hydrologic Alteration
LRO	Land Registry Office
Med GIG	Mediterranean Geographical Intercalibration Group
RBMP	River Basin Management Plan
PoM	Programme of Measures
QE	Quality Element
SCI	Site of Community Importance designated under the Habitats Directive 92/43/EEC
SPA	Special Protection Area designated under the Birds Directive 2009/147/EC
ToR	Terms of Reference
WB	Water Body
WDD	Water Development Department
WFD	Water Framework Directive, Directive 2000/60/EC

Table of contents

List of Tables

List of Figures

This project report is written in first person singular, in response to a condition imposed by the Assessment Panel of the project's viva voce examination.

Chapter 1. Introduction

The present DProf project deals with the management of rivers in Cyprus in the framework of the European Union's environmental policy and more precisely under the Water Framework Directive 2000/60/EC. This Directive foresees, amongst a multitude of other actions, the assessment of rivers' quality using a set of specified biota. For such assessments to be undertaken in practice, first and foremost the specific biota have to be present in the investigated rivers. However, thus far monitoring of Cyprus rivers has revealed that this is not the case in all of them, indicating the presence of different river types with respect to presence/absence of specific biota. Still, up to now, no attempt has been made to separate the river types where the biota are present from the rest; furthermore, official Cyprus' reporting to the E.U. so far gives the impression that the specific biota exist in all Cyprus rivers thus presenting a picture that does not correspond to the reality and that is prone to become an issue between Cyprus and the European Commission at some stage.

There is, therefore, a need to distinguish rivers where biota can be used for water quality assessment from those where this is not possible, in order to increase the degree of compliance with the Water Framework Directive's requirements on the island but also to improve the basis for river monitoring and management in Cyprus in general.

The very specific problem introduced above is, however, inextricably related with a number of other issues that are either prerequisites for rivers' assessment using biota under the E.U. Directive or actions that customarily follow the assessment itself, such as:

- Which rivers should be assessed in the first place?
- What are meaningful/useful management units and how to delineate them?
- How to assess those rivers that must be assessed but are not monitored?

All the above issues together may be called the "spatial basis for rivers monitoring and management" and need to be appreciated as a whole and subsequently improved in an integrated way. The present DProf project sets out to elaborate a proposal to improve the abovementioned problems and issues.

I have been working with river assessments for the implementation of the Water Framework Directive in Cyprus since 2007, in my position as a hydrologist at the Water Development Department. During this period, I was responsible for the organization and implementation of the related monitoring programmes in Cyprus but I had also regularly participated in related E.U. working groups as the Cyprus representative. I have, therefore, both the practical knowledge on the local level and the policy background to implement the abovementioned project.

The components of the “spatial basis for rivers monitoring and management”, as mentioned above, are critical elements for the elaboration of River Basin Management Plans, which are in turn integral parts of the implementation of the Water Framework Directive. The 2nd River Basin Management Plan is due by the end of 2015 and, therefore, the DProf project is very timely, because it will deliver an improved “spatial basis” in time to inform this management plan.

1.1 Context and rationale

1.1.1 Background - The Water Framework Directive 2000/60/EC

The Water Framework Directive 2000/60/EC (WFD, European Parliament and European Council 2000) was brought into force in 2000 and is considered one of the most ambitious and encompassing pieces of environmental legislation in the European Union (Liefferink et al., 2011) while it was “placed somewhere near the ‘high water mark’ of Community environmental legislation in respect of its innovative qualities” (Howarth, 2009, p.392). The Directive was praised for changing the water management paradigm in Europe because it institutionalizes ecosystem-based objectives as the overriding criteria in water policy and decision making (Kallis and Butler, 2001) by putting aquatic ecology at the base of management decisions (Hering et al., 2010). The statute combines institutional settings, economic tools, and biological requirements to foster integrated water management (Bouleau and Kondolf, 2011) and thus provides a standard set of guiding principles across Europe with the objective of achieving good ecological status by 2015 (Zalewski, 2011); with respect to achieving the WFD objectives, member states are allowed to extend the deadlines under certain circumstances to 2021 or 2027 (Albrecht, 2013).

Water management as defined by the WFD is based on hydrological units and the important management units are the water bodies: both environmental objectives and exemptions refer to these units (Petersen et al., 2009) and they are the basic units of status assessment (Lassaletta et al., 2010). Therefore, it is no surprise that the term “water body”... is essential for several aspects of the Directive’s implementation, such as the typology, the reference conditions, the monitoring and the classification of water status (European Commission, 2003a); the water body, as an entity, thus represents the link between these major components of the WFD’s implementation.

In order to achieve the Directive’s environmental objectives, Member States (MS) have to consult on and publish river basin management plans (RBMP) including Programmes of

Measures (PoM) which show how they will seek to restore a “good” ecological status to surface water bodies (Phillips, 2014). While the RBMPs reflect the whole planning process in the river basin, the PoMs set out the actions to be taken during the plan period to attain the Directive’s objectives (Albrecht et al., 2010). The Directive prescribes a 6-year management cycle for RBMPs and PoMs and foresees three cycles, with corresponding delivery deadlines in 2015, 2021 and 2027. Within each cycle, the main stages of implementation are:

- Characterization of the river basins and human impacts on them (Art. 5 WFD)
- Monitoring and classification of water status (Art. 8 WFD)
- Comparison with the objectives for the water bodies (Art. 4 WFD)
- Management and implementation of measures to achieve the objectives (RBMP Art. 11 WFD, PoM Art. 13 WFD)

According to Article 5 of the WFD, each E.U. Member State is required, amongst others, to identify bodies of surface water in its territory. These water bodies must fall within either one of the following water categories: rivers, lakes, transitional waters, coastal waters. Furthermore, for each surface water category, the identified water bodies need to be differentiated according to type. The result of the above procedure is, in the case of rivers, a river network that consists of river water bodies each of which belongs to a specific river type.

Article 5 of the Directive also requires that, for each surface water body type, type-specific reference conditions shall be established. These reference conditions represent the values of predefined quality elements for that surface water body type under “undisturbed” conditions showing no or only “very minor” human impacts. The reference conditions are subsequently used as the anchor of the classification system for ecological status (European Commission, 2003f).

According to Article 8 of the WFD, each E.U. Member State is required to systematically monitor a number of predefined quality elements in its waters: biological, physicochemical, hydromorphological and chemical. Member States are also required to develop the necessary assessment methods for all the quality elements, including biological quality elements (BQEs). Member States are additionally required to participate in the Intercalibration Exercise. In this exercise, Member States’ BQE assessment methods are compared and harmonized in order to ensure comparability of ecological status across the E.U. The mandate for the IC exercise was assigned by the European Commission to the Working Group on Ecological Status (ECOSTAT), in the framework of the E.U. Common Implementation Strategy (CIS) of the WFD.

The abovementioned quality elements are subsequently used to determine the ecological status of all water bodies that have been delineated according to Art. 5 of the Directive and by using the type-specific reference conditions as anchor point, as described further above. In particular and according to WFD Annex V, 1.4.1 (ii), ecological status shall be expressed as ecological quality ratios, which represent the relationship between the values of the biological parameters observed for a given body of surface water and the values for these parameters in the reference conditions applicable to that body (WFD), i.e. the water body's type-specific reference conditions. Thus, the main purpose of typology is to enable type specific reference conditions to be defined (European Commission, 2003f).

The status of water bodies represents crucial input data for the preparation of the River Basin Management Plan and the Programme of Measures, because a water body's status is the main criterion to decide whether measures for its improvement are required, or not, to achieve the environmental objectives set by the Directive.

The importance of the typology to reference conditions can be appreciated by considering the consequences of assigning the wrong type to a water body; "wrong" in this context means that the assigned type does not correspond to the reality on the ground (i.e. in the river). In such a case, this water body is subsequently assessed against a wrong benchmark and its status will not correspond to reality. But the worst consequence will materialize if, based on its - wrongly assessed - status, measures are required to improve the water body's status: these measures will be based on a wrong understanding of the "functioning" of the specific water body and will thus, most probably, be largely unsuitable to improve its status. Consequently, the money spent for the measures might be mostly or completely wasted. This clearly shows why the correct determination of the type of each single water body is fundamental for the real-time success of the WFD, apart from the legislative requirement to implement the Directive.

In Cyprus, the WFD was transposed into national legislation with the "Water Management and Protection Law" N.13(I)/2004 that specifies the Minister of Agriculture, Rural Development and Environment as the responsible institution for its implementation. Unified water management, on the other hand, was awarded to the Water Development Department by the "Unified Water Management Law" N.79(I)/2010 and the same law awarded to the Director of the Department the responsibility to make proposals regarding water policy to the Minister of Agriculture, Rural Development and Environment. Based on these provisions of law N.79(I)/2010, the Water Development Department is implementing the Water Framework Directive on the operational level.

1.1.2 Rationale

DISCLAIMER

Within this study, the following definitions for streams according to their surface flow durations are adopted. *Perennial* streams flow throughout the year, whereas *temporary* streams lack surface flow for some portion of the year (McDonough et al., 2011). Temporary streams are classified further into *intermittent* streams, with more or less regular seasonal discharge (Boulton, 1988, 1989, in Davies et al., 1994) that support biological quality elements according to the Water Framework Directive (WFD), *ephemeral* rivers where surface flows typically last only days to weeks (Boulton, 2014) and *episodic* rivers that only flow after unpredictable rainfall (Bayly and Williams, 1973, in Uys and O'Keeffe, 1997). Ephemeral and episodic rivers do not support the biological quality elements prescribed by the Water Framework Directive (WFD) and are, therefore, often used jointly, as one single term, in this study.

Significant shortcomings of the current monitoring programme for the implementation of Art. 8 of the WFD are rooted in deficiencies of the work that was carried out in the past for the implementation of Art. 5 of the WFD: the river typology, the corresponding river network determination and the subsequent river water body delineation (Karavokyris & Partners Consulting Engineers S.A. and Kaimaki, 2009). In that respect, the lack of quantitative knowledge of hydrological regimes of Cyprus rivers and, in particular, of the different types of temporary rivers is identified as one central issue. This lack is manifested firstly in the Cyprus river typology that was developed by WL | Delft Hydraulics et al. (2004) and was used for the 1st RBMP. This typology is presented in *Table* 1 below.

Table 1 : Cyprus river typology of the initial implementation of Art. 5 of the WFD and typology descriptors (WL | Delft Hydraulics et al., 2004).

River type	Annual rain volume	Flow continuity
R1	small (< 40 x10^6 m^3/yr)	non-continuous
R2	large (> 40 x10^6 m^3/yr)	continuous
R3	large (> 40 x10^6 m^3/yr)	non-continuous

Table 1 shows that, while two types of temporary rivers were differentiated (R1, R3), there is no distinction with respect to these types' flow regime: both are characterized as having "non-continuous" flow. One might assume that the distinction by "annual rain volume" would serve to distinguish flow regimes between the two types but practical experience with Cyprus' rivers shows that this is not the case: The rivers that had been assigned to each of the non-continuous types (R1, R3; WL | Delft Hydraulics et al., 2004) correspond to flow regimes ranging from (typical) intermittent to ephemeral/episodic, in each of the two types.

In the literature, the flow regime has been recognized to be one of the drivers of the ecological status of a stream (De Girolamo et al., 2011) and it plays a major role in the preservation and restoration of the components and processes of the river ecosystems (Bejarano et al., 2010). Navarro and Schmidt (2012, p.2) found that "virtually all rivers, lakes, wetlands and groundwater dependent ecosystems are largely controlled by the hydrological regime". Based on the evidence, one is tempted to say that it is perhaps even the most important non-anthropogenic, i.e. natural, driver and that it is likely to be decisive for the reference conditions of types of the aforementioned aquatic systems. With respect to Cyprus' rivers, in many cases pollution is marginal while flow alteration is severe. Thus, it becomes clear that a good understanding of the hydrological stressor is critical in order to tackle the challenge of ecosystem improvement for achieving the goals set by the WFD.

The river typology shown in *Table* 1 was also adopted for the implementation of Article 8 of the WFD, i.e. the monitoring programme, by the Ministry of Agriculture, Natural Resources and Environment (2007), considerable time after the establishment of the river typology (Ministry of Agriculture, Natural Resources and Environment, 2005). The lack of consideration of the flow regime and the fact that rivers with both intermittent and ephemeral/episodic flow regime had been included within single types had a large impact on the monitoring results, because it led to monitoring stations for which Cyprus had declared that BQEs would be monitored but in the end it turned out that these rivers, due to their short annual flow period, do not support BQEs. No assessment against the set reference conditions was possible in these cases because the BQEs do simply not thrive in these rivers, while in other rivers of the same type the WFD-specific biota flourish and status can be assessed using the reference conditions as anchor. The conclusion from this situation is that the set reference conditions for the two types R1 and R3 were not applicable for all water bodies that had been assigned these types. In addition, it is apparent from *Table* 1 that no type had been identified that would apply to those rivers that do not support BQEs.

Therefore, in order to rectify this situation, a fundamental revision of the Cyprus river typology is needed, which would become the basis for a sounder future monitoring programme so that river types would correspond to the applicability of BQEs and all feasible parameters would be measured in all sites.

The second related shortcoming of WFD implementation for rivers in Cyprus lies in the fact that during the delineation of the management units, i.e. of the river water bodies, the pressures acting on the water bodies were not taken into account. This led to a river network where many water bodies include both un-impacted stretches and stretches with considerable human pressures, and has led to large problems both for the classification of status and for the subsequent management of the water bodies, i.e. for the implementation of measures to improve status. In addition and from a normative perspective, water body delineations that hamper the assignment of a single water status to a water body, e.g. due to an inhomogeneous pressure situation acting on it, are not in line with the relevant WFD CIS Guidance Document (European Commission, 2003a). To address this deficiency, the river water bodies need to be re-delineated taking into account the pressures acting on them.

Even though the abovementioned shortcomings in Cyprus' WFD implementation up to now are of a very technical nature and give the impression of being mere "technical deficiencies", they provide insights beyond the technical realm. The fact that such significant and fundamental problems do exist in the classification and monitoring systems, which were established by the authorities who are responsible for the management of these very river systems, indicate a lack of understanding of the river systems themselves.

1.1.3 Approach for problem alleviation

This project sets out (a) to rectify the "technical deficiencies" mentioned above by elaborating recommendations for the introduction of a new spatial basis of rivers monitoring and management for the implementation of the E.U. Water Framework Directive in Cyprus and (b) to investigate the potential effects of their implementation. The new system that will be proposed will take into account hydrological regime in its river typology in a meaningful way for the application of Biological Quality Elements. To achieve this, it will establish a new typology for Cyprus rivers and subsequently the revised and typologically classified river network will be "cut" into water bodies based on existing pressures. This will produce updated river water bodies with, as much as possible, homogeneous pressure situations. The system will also include a new grouping scheme of river water bodies, where water bodies with similar pressure levels are joined into groups; the exact pressure levels will be established by relating pressures to measured water status, thus linking water bodies, water status and pressures together to yield a sound basis for the management of the water bodies. This grouping scheme will allow the estimation of the status of unmonitored water bodies from the data collected in monitored water bodies and will thus contribute to improved water status assessment procedures of unmonitored water bodies.

The above work corresponds to a part of the "review and if necessary update" of the analysis of the characteristics of river basins and human impacts on them, which is required under Art. 5 of the WFD to be carried out by the E.U. Member States until the end of 2013. Therefore, the project will provide this "review and if necessary update" as far as the typology, characterization and delineation of Cyprus river water bodies is concerned.

It is proposed that, for eventually implementing the recommended changes in rivers typology and network, the Director of the Water Development Department needs to adopt the proposed new system. It is also proposed that, for taking an informed decision, the Director of the WDD has to be aware of the benefits but also of the potential negative effects of the implementation of the proposed changes. Therefore, the benefits and potential negative effects will be investigated through a stakeholder consultation. Finally, the new river typology and river water bodies network will be presented to the Director of the WDD together with the potential benefits and the potential negative effects of its implementation.

As it becomes clear from the above, the project is embedded in the real-life implementation of the WFD in Cyprus. This includes the aspects of the temporal framework, as defined by deadlines and temporal specifications set by the Directive itself, the spatial framework, i.e. any recommendations have to cover the entire set of river water bodies addressing also any special cases or exceptions, as well as the normative framework, i.e. any recommendations have to conform to the Directive's prescriptions. These facts are important and have direct impact on the envisaged research because they limit the time available to research the topics and they also make clear that in cases where research findings may not provide clear answers, solutions must nevertheless be given, e.g. based on "expert judgement", to allow for the implementation of the WFD to proceed.

1.1.4 Originality

The research proposed above is original in the sense that it has never been tried in Cyprus yet to classify rivers according to their hydrological regime based on quantitative stream flow data. In particular the mapping of the spatial extent of temporary flow regimes in Cyprus and the description of these stream types with hydrological and catchment characteristics has not been attempted before in Cyprus. This component of the proposed project thus constitutes original research in the sense of Phillips (1993, in Phillips and Pugh, 2005) who considers trying out something in one country that has previously only been done abroad, as original research.

While there are numerous studies comparing various pressures to certain elements of water status, as far as I have found out, studies that focus on the relations between pressures and overall ecological status are rare; therefore, this project through its attempt to establish such relations makes an original contribution to scientific knowledge.

Another aspect of originality of the project is the application of action research in a virtual way and as a stakeholder consultation – such application is considered to be at least rare.

1.1.5 About the researcher

I completed a study course for a Diplom-Ingenieur[1] diploma in "Forestry-Watershed Management" at the University of Agricultural Sciences in Vienna and after its completion I moved to Cyprus for a student placement at a small consultancy company and the Water Development Department in Cyprus. I have been associated with the latter ever since. Initially, I had an engagement as a National Consultant of the Food and Agriculture Organization of the United Nations (FAO). I was based at the WDD and assisted with various parts of a major project on water resources assessment in Cyprus. I then decided to study for an MSc in "Water Resources" at the Centre for Arid Zone Studies of the University of Wales in Bangor and my MSc dissertation was again related to the Water Development Department, studying erosion and sedimentation in a major Cyprus water reservoir. Subsequently, I worked for several years as a freelance hydrologist in Cyprus, including contracts with the FAO and with the University of Cyprus.

Since 2006 I hold a permanent post, as a hydrologist, at the Water Development Department and I have accumulated considerable expertise in water resource monitoring: I am the officer in charge of the monitoring programme of Cyprus' surface freshwaters that is carried out for the implementation of Article 8 of the E.U. Water Framework Directive 2000/60/EC (WFD) since 2007. In the same year I was nominated as the Cyprus representative in the Working Group on Ecological Status (ECOSTAT). During this period, I was responsible for the development of assessment methods for a number of biological quality elements, for the successful participation of these methods in the Intercalibration exercise, for their implementation in Cyprus' WFD monitoring programme and I was deeply involved in the evaluation of the monitoring results produced by these methods, to determine the ecological status of Cyprus surface freshwaters. Besides the above, I am coordinating a number of other water monitoring programmes and I am the responsible person for the management of stream flow monitoring and the corresponding hydrometric station network in Cyprus.

My perspective of my professional field, hydrology, has undoubtedly been lastingly coined by the epistemological framework of hydrology as it was described, for example, by Maidment

[1] Graduate Engineer at MSc resp. MEng level

(1993, pp.1.1–1.2) who indicates that hydrology relies largely on the inductive methods of empiricism as it has to “sift the critical numbers from large amounts of observed hydrological data” and that “hydrology is thus an observational science” or by Jones (1997, p.5) who emphasizes “the benefits of observing processes and of building predictive models based upon those observations” in hydrological science. The above statements about hydrology as a science do represent, to a large extent, my personal view on hydrology as a profession in general and on knowledge generation within the discipline in particular and the fact that I have been in contact with the specific field of hydrometry and water resources monitoring for more than a decade probably biases my view of hydrology towards its observational component and thus towards empiricism.

My perspective is a post-positivist one, as described by Kovarsky and Crago (1990, p.46): “Postpositivists have considered knowledge as converging on truth with no absolute certainty attainable. From their perspective, science proceeds by induction rather than deduction. Theory derives from or is grounded in data and partial formulations” and, as it was pointed out by Pickett et al. (2007), a continuous dialogue between observable phenomena and conceptual constructs is required for theory maturation. My epistemological paradigm is post-positivist also in the sense that, while observation is theory–laden (Rhoads and Wilson, 2010), data or evidence preserve objectivity of testing because “theory - dependence does not threaten objectivity but, instead, provides the basis for collection of appropriate observations for theory testing” (Rhoads and Thorn, 1996).

In my specific professional field, water resources monitoring, I follow an empiricist-inductive professional approach, in the sense that the sum and integration of measured environmental information allows for a truly holistic understanding of ecosystem processes in a specific environment or region; this, in turn, serves as a sound basis for protection, management and development decisions. I am aware that, undoubtedly, this approach subconsciously influences my decisions towards methods that rely on data rather than on e.g. modelling approaches; still, I consider it important that the project is not only scientifically sound but also consistent with my beliefs.

1.1.6 RAL claim at level 8 for “Advanced developments in professional practice”

I have successfully submitted a RAL claim at level 8 for 120 credits for my work on the “Development, organization and implementation of the monitoring programme for Biological Quality Elements in Cyprus surface freshwaters, according to Article 8 of the E.U. Water Framework Directive 2000/60/EC”. This encompasses my work as responsible officer at the WDD for the development of assessment methods for a number of biological quality elements, for the successful participation of these methods in the Intercalibration exercise, for their implementation in Cyprus' WFD monitoring programme and my deep involvement in the evaluation of the monitoring results produced by these methods, to determine the ecological status of Cyprus surface freshwaters. As it becomes clear, the work presented for my RAL claim has direct relevance to this project, which deals with water resources monitoring under the above-mentioned Water Framework Directive, and can in fact be considered to have laid major part of the basis of the present project.

1.2 Aims and objectives

The project sets out to investigate shortcomings of the implementation of the Water Framework Directive 2000/60/EC (WFD) in rivers in Cyprus and to elaborate recommendations to rectify them. The project also sets out to investigate the benefits and potential negative effects of the implementation of the proposed recommendations.

In particular, it will investigate the problem of insufficient river typology by carrying out a fundamental revision of it. It will also explore the problem that many river water bodies include both un-impacted stretches and stretches with considerable human pressures, and the subsequent difficulties for the classification of status and for the management of these water bodies. The above work corresponds to the "review and if necessary update" of the analysis of the characteristics of river basins and human impacts on them, that is required under Art. 5 of the WFD and has to be carried out by the E.U. Member States until the end of 2013.

It is noted that the "review and if necessary update" of the "economic analysis of water use", which is also required under Art. 5 of the WFD by end-2013, is **not** part of the DProf project.

The recommendations to rectify the specific problems of implementation of the WFD, together with the anticipated benefits and potential negative effects of their implementation, will be proposed to the Water Development Department, which is the authority in charge of implementation of the WFD in Cyprus.

While the implementation of the abovementioned recommendations is not part of the DProf project, the recommendations together with the potential effects will be proposed for adoption to the Director of the WDD.

The aim of the DProf project is to elaborate recommendations for the introduction of a new spatial basis of rivers monitoring and management for the implementation of the E.U. Water Framework Directive in Cyprus and to investigate the potential effects of their implementation. This new spatial basis is proposed to be in the form of a new river water bodies network that will take into account hydrological regime and pressures.

The specific objectives of the DProf project are:

- Objective 1: To elaborate a new typology for Cyprus rivers, based on their hydrological regime. The types of hydrological regime that will be proposed should be based on characteristics that have a significant relation to the aquatic ecosystem. This will ensure the attribution of applicable Biological Quality Elements for water bodies' monitoring and status assessment to each river type.
- Objective 2: To delineate river water bodies based on the newly developed river typology and on pressures. The newly delineated river water bodies should be characterized by homogeneous hydrological regimes and, as much as possible, homogeneous pressure situations in order to facilitate their efficient monitoring and management.
- Objective 3: To elaborate a water body grouping scheme that will contribute to improved water status assessment procedures for unmonitored water bodies.
- Objective 4: To collect information, from major stakeholders but also from other supporting sources, on anticipated benefits and potential negative effects of the proposed new river water bodies network.
- Objective 5: To present and recommend the new spatial basis of rivers monitoring and management for the implementation of the E.U. Water Framework Directive in Cyprus, as well as the potential effects of its implementation, to the Director of the Water Development Department, for adoption.

1.3 Outcomes and intended impact

In terms of *practical products,* the project is anticipated to generate the following:

- A river network of Cyprus, classified according to hydrological flow regimes (e.g. perennial, intermittent, ephemeral). For each river or for each significant stretch of river, the hydrological regime will be given. The outcome will be both textual, i.e. in the form of a description of each river type and also in the form of a map, which will show the spatial extent of the river types. A description of the derivation process of the river types will also be produced.
- A network of river reaches, geometrically based on the river network above, where each river reach is exposed to a more or less homogeneous pressure situation. The river reaches will be grouped into groups of hydrological types and typical pressure situations. The outcome will be in the form of a map showing the river reaches and in the form of tables describing the pressure situation of each river reach.

- A network of river water bodies, geometrically based on the river reach network described above, appropriate for WFD implementation in Cyprus and compliant with WFD requirements. This outcome will be in the form of a map showing the spatial extent of each river water body and also in the form of tables giving characteristics of each river water body.
- A description of the anticipated benefits and potential negative effects of the implementation of the new spatial basis of rivers monitoring and management.
- Recommendations for the BQEs to be monitored in each river type, in particular justifications why certain BQEs cannot be monitored in certain river types.

The immediate ***impact***, to be effected within and as part of the project, is the transition from one river water body network to another, where the latter is largely more suitable and more adapted to local conditions. It is anticipated that there will also be a significant impact in the long term, outside of the scope of the project, because river management in Cyprus will be carried out on a more robust and appropriate basis.

The outcomes of the project are not of a kind that has wide applicability except for national authorities responsible for river management, other bodies and stakeholders involved in river management or water use and for the academic community involved in river research. In response to this, ***dissemination*** will be in the following two forms:

- Publication of the final results on the WDD website.
- Presentation of the results to the local Cyprus community involved in river monitoring, management and research.
- Relevant parts of the project will be included in the second Cyprus River Basin Management Plan, to be submitted to the European Commission by the Republic of Cyprus.

Chapter 2. Review of literature

This literature review is intended to serve purposes that include finding out potential methodological approaches for the project, showing where the project fits and how it relates to the approaches of other researchers and providing the project's context through discussion of relevant literature; the literature review thus roughly follows the DPS 4561 handbook (Middlesex University, 2011) and it will be undertaken following the sequence of the main activities, components and issues of the project, after an introductory review of the legal framework.

The approach for the selection of the publications discussed in this chapter, but also in the DProf project report generally, is described in the following paragraphs.

There is a huge amount of literature available about the Water Framework Directive. According to Moss (2008, p.35), about 1000 papers have been published in ISI listed journals that have "Water Framework Directive" in their title or key words between 2001 and 2008 and "it has become almost mandatory to refer to the Directive in any paper concerned with applied aspects of aquatic ecology in Europe"; the number of papers has certainly increased further since 2008 as the implementation of the WFD went ahead and tackled more and more of the Directive's details and aspects. Even though "many of the published papers are detailed studies of components of freshwater habitats ... that defer to the Directive as requiring measurements or assessments of these components" (Moss, 2008, p.35) and are therefore not directly relevant for the DProf project, all these papers still show up in library or journal searches when simple keywords such as "Water Framework Directive" are used. Such simple searches, therefore, lead to very long lists of unspecific results and were not suitable for the literature searches of the DProf project. To overcome the problem, I resorted to multi-part search strings that allowed a more targeted retrieval of potentially pertinent literature.

I accumulated the information on the technical aspects of the DProf project over a long time period due to my professional work, long before I had started the DProf programme. This collection had been completed and utilized for the project planning module DPS4561 and was largely extended and updated during the DProf project to close gaps and to cover all necessary details. For the stakeholder process, all literature was collected specifically for the DProf project. While the main literature search and review of the DProf project took place early in the project, keeping up to date with the literature on the topics continued throughout the whole period of the research (cf. Gill and Johnson, 2002).

With respect to the scope and type of information, the literature exploration was pursued along the following main axes:

- E.U. normative documents (Directives, Commission Decisions, etc.)
- Non-binding official E.U. documents (e.g. WFD CIS Guidance Documents)
- Official communications between the E.U. and the Republic of Cyprus
- Pertinent technical reports from other E.U. Member States
- Reports from pertinent research projects
- Academic papers from peer-reviewed journals

Keyword searches with multi-part search strings were undertaken for each DProf component in Middlesex University's online library catalogue but also in google scholar and in the "normal" google search engine. Papers that were identified but were not available as full text in Middlesex University's online library catalogue were routinely looked for on ResearchGate and Academia.edu. Some hard-to-find publications were requested directly from their authors, as author copies, and all relevant papers were finally retrieved.

For each component-specific literature search, the most obvious keywords for the topic being researched (e.g. the name of the topic itself) were used first, concatenated with e.g. "WFD" to form a complex search string that limited the search results. Subsequently, further keywords were identified by reviewing the first suitable and pertinent publications found and the search was continued with them. Promising references that were identified in retrieved publications were also routinely looked up.

Well above 800 publications were retrieved and reviewed, in the course of the DProf project, for the selection of the papers that were finally utilized and discussed in the project report. This number includes many papers that were recognized as irrelevant very quickly, during the first quick screening of the retrieved papers. Nevertheless, the large amount of publications rendered the literate review a long, time-consuming yet necessary process to select the most relevant publications in relation to the project.

2.1 Legal framework – The Water Framework Directive and related documents

The DProf project's purpose is to improve some aspects of the implementation of the Water Framework Directive (WFD; European Parliament and European Council, 2000) in Cyprus. This E.U. Directive was brought into force in 2000 and it was praised for changing the water management paradigm in Europe because it institutionalizes ecosystem-based objectives as the overriding criteria in water policy and decision making (Kallis and Butler, 2001) and it puts aquatic ecology at the base of management decisions (Hering et al., 2010).

However, the WFD has also been criticized for various aspects. For example, Hatton-Ellis (2008) focused his critique on the procedures prescribed by the WFD for calculating water status and feared that European environmental standards would be erected on the basis of statistical distributions rather than on ecological impacts. The critique of Moss (2007) targets the reductionist approach that has been the traditional approach of water managers. He claims that such an approach to WFD implementation would be the wrong way, even though it is understandable due to its tradition in the professional field, and he makes a pledge to respect the spirit of the Directive instead. This argument reflects to a considerable extent the situation in the DProf project. The simplifying reductionist approach has tradition in river management at the WDD and I feel that the ecosystem approach I promote represents the "spirit of the Directive" as described by Moss (2007).

The temporal horizon of the WFD was criticized by Hering et al. (2010, p.4017) who judged the overall aim of reaching good water status to be "ambitious but not realistic in the given timeframe". Here it should be taken into account that the authors of Hering et al. (2010) have all been involved in WFD CIS Working Groups and were thus actually driving significant aspects of WFD implementation. It would thus be expected that they tend to present the issues in a more favourable light than what the reality is and from their statement one can conclude that the achievement of the goals of the WFD seems to move to a distant future.

Due to the complex nature of many aspects of the WFD, 31 Guidance Documents have been published by 2015. For the present project, the Guidance Document No 2. "Identification of Water Bodies" (European Commission, 2003a) is particularly important because it prescribes rules for the delineation of water bodies. In that respect it explicitly points out that the "purpose of identifying water bodies is to accurately describe the status" (European Commission, 2003a, p.9) and thus relates the water body delineation to pressures and impacts, which is of special importance for the project. Guidance Document No. 10. "Rivers and Lakes – Typology, Reference Conditions and Classification Systems" (European Commission, 2003f) is also significant for the project because it provides guidelines on the establishment of water body types. Guidance Document No. 8 on public participation (European Commission, 2003e) may give some indications for the project but as it refers to the typical formal WFD consultation process, which the consultation proposed for the DProf is not, this document may be of limited value only for the project. As it is understandable from the age of the documents, their provisions are on a rather simple, but still valid, level. The abovementioned Guidance Documents and possibly others are crucial for the project and need to be taken into account as they are part of the normative basis of the WFD implementation process. In the light of the DProf project, the Directive's requirement for public information and consultation (European Parliament and European Council 2000, Art. 14) is important. Even though the involvement of interested parties is explicitly required for the River Basin Management Plans only, I believe that this general principle should be acknowledged as much as possible for WFD implementation.

2.2 *Development of spatial basis for river monitoring and management - technical part*

2.2.1 Identification of the location and boundaries of water bodies under the Water Framework Directive

As far as the legal basis is concerned, E.U. Member States are required to identify the location and boundaries of water bodies according to Article 5 and Annex II of the WFD. The sum of the identified water bodies makes up the river network of an area for purposes of WFD implementation. A review of the approaches used in other E.U. Member States to comply with the above requirements was undertaken to provide a baseline for the approach to be developed and applied in this study; its outcome is presented in the following paragraphs.

In Ireland, System B had been used for the river typology, and river water bodies with catchments less than $10km^2$ were not delineated as discrete water bodies (Office of Environmental Assessment, 2005). It is noted, however, that these river stretches are part of the catchment area of the next downstream river water body and in this way they are integrated into the Article 5 characterization. This seems to indicate that the Irish characterization does include watercourses that have catchments smaller than $10km^2$, though as upstream continuation of larger rivers. The Office of Environmental Assessment (2005) also mentions that coastal streams with catchments less than $10km^2$ were not delineated.

The same $10km^2$ catchment size criterion has also been applied in Northern Ireland (Environment and Heritage Service, 2005), though System A had been applied for river typology.

In England and Wales, a size threshold of $10km^2$ for river catchment area was applied to identify what is referred to as baseline water bodies and river types are defined according to system A (Defra, 2005, p.10). In addition, rivers with catchments smaller than $10km^2$ and that are not part of a larger catchment, but with a river stretch greater than 1 km in length, have been identified as water bodies. This work was undertaken at the 1:50,000 scale.

River types in Scotland are defined according to system A of the WFD and the size threshold of $10km^2$ river catchment area was used to identify baseline water bodies. The length of baseline rivers is measured to their source, as mapped at the 1:50,000 scale (SEPA, 2005). In addition, SEPA (2005) has identified and assessed additional 580 small rivers, which were justified by environmental concerns and to meet the requirements of regulatory legislation such as for drinking water supplies.

From an inspection of the Scottish river water bodies on the Scottish internet website (SEPA, 2011) it seems that stream orders had been used. At the upstream end of each 3rd order stream, each 2nd order stream continues up to its farthest source. For downstream tributaries, it seems that both the 1km stream length threshold and the $10km^2$ threshold were used. Also, the rule on 3rd and 2nd order streams lined out above seems to have been applied. However, 2nd order streams joining a 3rd order stream along the latter's course, which have length < 1km seem not to have been identified as water bodies.

For the United Kingdom, a guidance on the identification of small water bodies was published (UKTAG, 2003a) as well as a guidance on the typology of rivers (UKTAG, 2003b). Also for the UK, the Department for Environment, Food and Rural Affairs, the Department of the Environment Northern Ireland, and the Scottish Executive & Welsh Assembly Government (2005) had published a note pointing out the continuous nature of water body characterization and especially noted that the identification and characterization of further important smaller water bodies which fell below the size or priority thresholds during initial characterization, will be an issue to be dealt with after the initial characterization.

In Malta, only one river type (calcareous, small, temporary) was identified (Malta Environment and Planning Authority, 2005) and each of the altogether three river water bodies have a length of < 2km.

In Austria, Wimmer et al. (2000) had established surface water types, in accordance with the draft of the EU Water Framework Directive, based on aquatic landscape units that were elaborated using running waters with a catchment area greater than $10km^2$. For the final implementation of the WFD several years after the report of Wimmer et al. (2000), Austria was applying system B for its river typology and developed this for all rivers, i.e. also for the ones with a catchment area smaller then $10km^2$. The hydrological regime had also been taken into account and the river types were checked and adjusted according to biological data, leading to river types that can be distinguished based on their specific aquatic biocenoses (BMLFUW, 2005, p.69)

Germany was applying system B (Borchardt et al., 2006) though it was applied with very different criteria in the German federal states. In the report of Borchardt et al. (2006) it is not mentioned whether a minimum catchment size was used in Germany. The average length of a river water body is slightly below 20km and a minimum length criterion of 1km for the designation as HMWB was widely used.

The above thresholds e.g. the 10km^2 dealt with the size that a catchment must have to be considered for the WFD stream network. Still, another question to be answered was how to treat headwater streams, i.e. how to delineate the "upstream end" of the stream network. The importance of headwater streams was highlighted by several writers e.g. Finn et al. (2011) who found that, on average, headwaters probably contribute disproportionately to biodiversity at the network scale; the mention of the network scale is especially important for the DProf because the study looks exactly at this scale.

2.2.2 River typology under the Water Framework Directive

Appropriate river typology parameters for the purpose of the WFD

The WFD specifies that water bodies shall be differentiated according to type using such descriptors as are required to derive type specific biological reference conditions (European Parliament and European Council 2000, Annex II). As descriptor, the WFD allows any natural environmental parameter influencing biological communities to be included in the typology system and, therefore, a wide variety of typologies was to be expected (Hering et al., 2010) and indeed, the different criteria followed in different regions has fostered a patchy implementation of the WFD and has resulted in recognition of temporary waterways in few river basin districts in the E.U. (Acuña et al., 2014). It was even speculated that between the E.U. Member States "most likely the individual typologies are not comparable at all" (Hering et al., 2010, p.4012).

The typology concept introduced by the WFD did also earn considerable critique. For instance, Hatton-Ellis (2008) denounced the prescribed typology framework indicating that freshwater systems tend to be distributed along gradients rather than within discrete ecological types. The critique of Moss (2007, p.382) was focused on the same aspect, and he compared the categories to be set up according to the typology concept as "compartments in a pigeon-loft" or "boxes in the mailroom" and went on to a more general critique stating that in the WFD "twenty-first century environmental idealism was combined with mid-twentieth century, or even earlier, limnology" hinting at the, in his view, simplistic ecological concepts underlying the WFD. Of course, these views need to be seen through the prism of the authors' professions: Tristan Hatton-Ellis is a freshwater ecologist while Brian Moss is a limnologist and they, therefore, represent the ecological side of the community that implements the WFD. While their views are certainly valuable and need to be kept in mind as reminders of the spirit of the WFD, my personal experience in practical implementation of the Directive puts me in a position to see the merits of a certain degree of simplification of the ecological reality too.

With respect to what would be "appropriate" typologies to be established, Hering et al. (2010) highlighted the dilemma that on the one hand typologies are an appropriate tool for managers or the public while on the other hand they are coarse delimitations because natural systems follow continuous gradients and it is difficult to draw the border line where one type stops and another begins. As far as the DProf project is concerned, the aim is to have broadly defined types, easily understandable for managers and the public, that must however at the same time relate to the biological quality elements. This approach seems to be supported by Moss (2008, p.32) who maintains the view that there should be one unique stream typology for all BQEs when he criticizes that typologies are being "corrupted with different typologies used for different determinants." Still another supportive conclusion for broad types can be drawn from Boix et al. (2010) who found that the BQEs phytobenthos, invertebrates and fish responded differently to hydrologic alterations; this result would support the approach of one simple, over-arching hydrologic typology because it seems impossible to establish one that would suit all three BQEs. The lack of clear thresholds in the response of biota communities to flow intermittence found by Datry et al. (2014) also support an over-arching typology based on hydrological characteristics for mainly temporary rivers, as is the case in Cyprus rivers. In fact, Datry et al. (2014) based on their above findings concluded that defining intermittent rivers on the basis of biota alone may be difficult or inappropriate.

The references cited above already included some hints on the relation between the aquatic biota and the hydrology of rivers. More specifically, Statzner and Higler (1986) found, on a world-wide scale, that physical characteristics of flow are the most important factors governing the spatial distribution ("zonation") of stream benthos and that distinct changes in species assemblages are often linked to changes in parameters associated with stream hydraulics. Similarly, Poff and Ward (1989) concluded that floods, flow intermittency and flow variability can influence populations and community patterns of stream organisms. Based on their work mentioned before, they went on (Poff and Ward 1990) to suggest to use historical stream flow data, together with some other characteristics, to characterize "physical templates of lotic systems". Several years later, Poff et al. (1997) in their seminal paper on "the natural flow regime" described how the flow regime organizes and defines river ecosystems. They emphasized the decisive role that the movement of water and sediment plays for the definition of the habitat and subsequently for the aquatic biota. Gallart et al. (2008) studied seven Mediterranean streams and refer to the same relationship, but in the opposite direction: They state that the flow regime classification method they used had been designed for ecological purposes but that it would be useful to identify aspects of the stream regime such as the role of groundwater or snowpack melt.

From the above it becomes clear that characteristics of river flow regime are appropriate, and probably even the most desirable, parameters for river typologies, which are both beneficial and compliant with the WFD, and they, therefore, lend themselves to be used for the purpose of the DProf. In practical terms, such flow regime classifications group streams and rivers into classes, or types, within which key attributes of flow variability are relatively homogeneous (Snelder et al., 2009). Of course it needs to be noted that river flow regimes vary along a continuum and a classification into categories is not more than a simplification for practical management purposes.

On the question what specific hydrologic parameters are advisable to be considered for ecologically relevant river typologies, the arguably most influential work is the one of Richter et al. (1996). They presented an approach to statistically characterize hydrological regimes using 32 ecologically relevant hydrologic parameters, which they called the "Indicators of Hydrologic Alteration" (IHA). For the calculation of the IHA parameters, software is freely available on the internet (The Nature Conservancy, 2009). The IHA parameter set has been widely used in recent similar studies (e.g., Monk et al., 2008, Oueslati et al., 2010, Monk et al., 2011, Belmar et al., 2011, Oueslati et al., 2015) and it seems, therefore, well justified to be considered as one option to characterize Cyprus rivers in the framework of the DProf project. From their study of 60 rivers in the Mediterranean region, incl. 13 from Cyprus covering a wide range of Cyprus conditions but under-representing perennial streams, Oueslati et al. (2015) found that generally, perennial streams are mainly described by high flow indices, while temporary streams are described by duration, variability and predictability indices.

Apart from the IHA parameters, another hydrological parameter that could potentially be used in the project is the flashiness index (Baker et al., 2004) which has already been successfully applied to Mediterranean rivers (De Girolamo et al., 2008, Oueslati et al., 2010, Oueslati et al., 2015).

The Temporary Stream Regime Tool (TSR-Tool) was developed in the framework of the MIRAGE project by Gallart et al. (2012). It was subsequently applied within the MIRAGE project with modelled data to a catchment in Greece (Cazemier et al., 2011) while Tzoraki et al. (2014) had applied it to one catchment in Cyprus. Consequently, this method seems worth considering for the DProf project.

An approach for the classification of flow-regimes of intermittent streams in France using the two parameters mean annual frequency of zero-flow periods (consecutive days of zero flow) and mean annual total number of zero-flow days was reported by Snelder et al. (2013). For the intermittence classification, they grouped the stations into three subclasses that corresponded to subdivisions of a scatter plot of the two metrics. Being a graphical method using two metrics on a scatter plot and graphical subdivision into subclasses, methodologically it is quite similar to the Temporary Stream Regime Tool (Gallart et al., 2012); interestingly, both methods seem to have been developed at about the same time.

Temporary rivers in river typologies

The majority of Cyprus' rivers exhibit non-continuous flow, constituting 89% of the length of the river network reported to the E.U. (Ministry of Agriculture, Natural Resources and Environment, 2005). Cyprus is of course not an exception in the Mediterranean region, where river flow generally varies from perennial to ephemeral (Hooke, 2006) and where temporary rivers constitute significant water resources in the region (Tzoraki and Nikolaidis, 2007). In addition, in most catchments, some or all tributaries are either intermittent or ephemeral (Froebrich, 2005). Nevertheless, the WFD does not specifically address intermittent rivers but writers have pointed out that the Directive's requirement to assess ecological status of all surface waters includes intermittent rivers (Snelder et al., 2013) and that it is necessary to include intermittent rivers and intermittent reaches of larger river basins in the WFD management schemes (Skoulikidis et al., 2011); both publications do not define exactly their understanding of "intermittent" but as they do not refer to ephemeral rivers in their papers, it can be assumed that by "intermittent" they mean all stream types apart from perennial rivers, i.e. both intermittent and ephemeral/episodic rivers according to the terminology used in this study. In a comparison of Mediterranean river basin districts (RBD) in the European Union, Acuña et al. (2014) found that intermittency of flow had been considered in five out of seven RBDs.

Recognizing the abundance and thus importance of temporary streams in Cyprus, it is proposed in the present project to lay special emphasis on these rivers and on the investigation of their different types. Such a typology and its sub-types would need to cover streams that rise in better-watered areas but end in arid or semi-arid zones (allogenic), which is a common situation in Cyprus, as well as those that originate within arid or semi-arid zones (Davies et al., 1994); therefore, in the sense of Uys and O'Keeffe (1997), such a typology needs to envelop the whole continuum of river flow regimes where perennial and episodic/ephemeral rivers represent either end, separated by a suite of intermediate flow regimes. Within the temporary flow domain, Boulton (1988, 1989, in Davies et al., 1994) had distinguished "intermittent" rivers, with more or less regular seasonal discharge, and "ephemeral" or "episodic" rivers, which flow only after unpredictable rainfall. The criterion for this "simple distinction" was found to be of "special biological significance" (Davies et al., 1994, p.491) and thus this distinction seems applicable for the present study and for WFD purposes too.

For the purpose of the WFD, the further differentiation of intermittent rivers makes sense taking into account the results of Bonada et al. (2007) who found several biological macroinvertebrate metrics differed between permanent, intermittent and ephemeral sites. Similar results were reported by Argyroudi et al. (2009) who could clearly distinguish communities of the BQE benthic invertebrates in ephemeral and intermittent rivers. The problem with their study is that they do not give quantitative attributes of the ephemeral and intermittent rivers they have investigated. In any case, the above results pose problems with respect to the E.U. Intercalibration Exercise, where all intermittent rivers were treated in one group. A further division of temporary rivers into subgroups would also be justified according to Sánchez-Montoya et al. (2012) who studied physico-chemical conditions in Mediterranean rivers.

Methodologies and examples for the establishment of river typologies

Olden et al. (2012) have reviewed the process of hydrologic classification and differentiate between a deductive approach, using regionalization and environmental classification, and an approach based on inductive reasoning using stream flow classification, whereby hydrologic data are analysed directly. From these two approaches, Bejarano et al. (2010) had already concluded that the latter is preferable. They advise to incorporate flow data into the classification if it is available and note that those classification systems that only use physical variables run the risk of missing some important ecological features of the hydrological regime. Following Bejarano et al. (2010) and because stream flow data are available for Cyprus streams, it seems wise to utilize these stream flow data for the typology to be derived in the DProf project.

From the above survey of the literature it became clear that specific characteristics of stream flow are appropriate to establish stream typologies. Further investigation to answer the question “how exactly are these characteristics used by researchers to determine the different river types?” reveals that a great number of studies have utilized statistical cluster analyses to accomplish this task. I have identified the first references to the use of a clustering techniques to identify stream classes in the works of Haines et al. (1988) on the “global river regime classification” and of Poff and Ward (1989) who applied the approach to streams in the United States. More recent applications are described by Bejarano et al. (2010) and Alcázar and Palau (2010), both for the Ebro basin in Spain, by Baeza Sanz and García del Jalón (2005) for the Spanish part of the Tagus (Tejo) river, by Snelder et al. (2009) for French rivers, by Chinnayakanahalli et al. (2011) for streams of the western United States and by Oueslati et al.

(2010) and Oueslati et al. (2015), who worked with stream flow data from several Mediterranean countries. In addition, in several of the studies, Principal Component Analysis (PCA) was used to minimize redundancy and to reduce the dataset in general, to determine the significant variables (Bejarano et al., 2010, Baeza Sanz and García del Jalón, 2005, Snelder et al., 2009) and to identify those characteristics that contribute most to the data set's variance (Alcázar and Palau, 2010).

With respect to the methodologies applied in the above papers it is interesting to note that despite the statistical methods used, final decisions were taken rather subjectively in some cases. For example, Snelder et al. (2009) mention that the regime classification they obtained depended on subjective decisions, such as choice of clustering strategy, and that it is not possible to guarantee that other workers would arrive at exactly the same solution. In a similar way, Baeza Sanz and García del Jalón (2005) describe how they have decided on the basis of their knowledge of the rivers which clustering result of the flow regimes was the one with the greatest hydrologic sense. From these statements in peer reviewed papers, it can be concluded that in investigations into these subjects it might be necessary to rely on subjective decisions to arrive at meaningful results, based on my experience; it can, therefore, not be ruled out that subjective decisions may have to be taken in the DProf project.

As far as existing river typologies are concerned, it was found that official documents describing river typologies in E.U. Member States, in particular from non-English speaking countries, are mostly undiscoverable. Luckily, some national typologies are mentioned in scientific papers. For example, the Portuguese national stream typology is given in Dodkins et al. (2012), the typology of the Catalan River Basin District is presented by Munné and Prat, (2004) while the Italian stream types are presented by De Girolamo et al. (2011).

An example of a classification scheme for temporary wetlands is given by Yavercovski et al. (2004). Their scheme, modified from Boulton and Brock (1999, in Yavercovski et al. 2004), includes quantitative indications, in terms of years, of the timescales of wet and dry periods related to regimes like intermittent, episodic and ephemeral. Such quantitative classifications are rather rare in the literature and, therefore, this scheme could serve as a basis of the river typology for intermittent rivers to be established within the DProf project. Similar river typology schemes, though without specific timescales for each type, are presented in e.g. Poff and Ward (1989) and in Gallart et al. (2012).

2.2.3 Mapping of river types onto stream networks

With respect to the mapping of stream types respectively flow regimes onto stream networks, Snelder et al. (2009) remarked that there has been little development of methods and they themselves embarked on extrapolating the classification of the gauging stations to all segments of the river network of continental France, i.e. covering all flow regimes, using a type of regression model.

Few years later, the same river network and environmental variables and similar statistical methods that had been used by Snelder et al. (2009) were used by Snelder et al. (2013) to identify relationships between flow intermittence and catchment characteristics. Despite using the same methods and models, model performance was much worse and they concluded that "different suites of environmental variables are needed to model intermittent flows and whole flow regimes" (Snelder et al., 2013, p.2696) and that, while processes at a range of scales are involved, small-scale processes determine intermittence. They further argue that, when flow intermittence is related to groundwater dynamics, small-scale spatial data of e.g. aquifer structure and riverbed permeability may improve prediction of intermittent flow types but that such data are only rarely available. Thus, while the methods used by Snelder et al. (2009) perform well in situations with predominantly perennial river types, they achieve significantly less when dealing with mostly or exclusively temporary flow regime types that are much more influenced by local conditions and peculiarities. This fact had already been recognized by Hansen (2001, p.44) who remarked that "unusual circumstances can complicate stream type identification", e.g. perennial streams may be interrupted as flow travels underground in deep channel substrates. Hansen (2001) concluded that field verification is the only reliable way to determine stream types and their extent.

In Australia, Kennard et al. (2008) had used a classification and regression tree (CART) analysis with various sets of geographic and environmental variables to discriminate between flow regime classes, while Mackay et al. (2012) spatially extrapolated a low-flow hydrological classification to generate a map by using a vegetation index.

In a comparative study of six flow regimes classifications that were mapped onto the same digital river network, Snelder and J. Booker (2013) found that from a practical point of view, differences were not large and that there are many credible classifications of the flow regimes of a region. Concluding form this finding, they pointed out that for deciding on a specific approach, aspects other than the performance in predicting stream type (i.e. flow regime) for ungauged river reaches, such as flow data requirements and how easily the final classification can be explained, should be considered.

2.2.4 Water body grouping – pressure-status relationships

According to WFD CIS Guidance Documents no. 2 (European Commission, 2003a, p.21) and no. 7 (European Commission, 2003d, p.16), water bodies may be "grouped for monitoring, reporting and management purposes where monitoring sufficient indicative or representative water bodies in the sub-groups ... provides for an acceptable level of confidence and precision in the results of monitoring, and in particular the classification of water body status". Furthermore, Guidance Document no. 7 (European Commission, 2003d, p.12) also states that while monitoring "must permit the classification of all surface water bodies", this "does not mean that monitoring stations will be needed in each and every water body" but requires the Member States "to ensure that enough individual water bodies of each water body type are monitored".

In the sense of the above guidance, the Cyprus river water bodies that had been delineated by WL | Delft Hydraulics et al. (2004) were assigned to water body groups in the course of the project for the implementation of Article 8 WFD (WL | Delft Hydraulics et al., 2008). However, attempts to use these water body groups for status classification of the first RBMP encountered numerous problems. "The grouping of the water bodies ... contains serious weaknesses, because water bodies of different type, and subsequently different biological and hydrochemical characteristics are categorized into the same water body group" and "consequently, the projection of biological and hydrochemical findings, i.e. of the status, is not always possible from one water body to another within the same water body group" (Karavokyris & Partners Consulting Engineers S.A. and Kaimaki, 2009, p.100).

While I believe that grouping schemes for water bodies exist in the E.U. Member States, I did not identify any such schemes in this literature review, perhaps due to language barriers because they might be described in the Member States' languages only. In addition, the literature review also revealed that the establishment of such grouping schemes was not addressed by the academic community either. This gap has been highlighted by Reyjol et al. (2014) who identified a need to develop models for the spatial extrapolation of ecological status. Such models would allow predicting status in water bodies that are not directly monitored, i.e. without directly measuring biological and chemical quality elements. Reyjol et al. (2014) go on to identify the development of models relating biota to pressures as one crucial issue towards achieving spatial extrapolation of ecological status.

The relations between pressures from human activities (agriculture, urbanization, etc.) and ecological status in European rivers had been addressed, amongst others, in the FP6 project REBECCA. In this framework, Garcia et al. (2004) found the problem to be complex for two reasons: (a) The criteria to identify and assess pressures must be based on available data but many pressures are difficult to identify and measure, and (b) The influence of scales when studying ecological processes in large spatial contexts, e.g. the upscaling of ecological relationships. Garcia et al. (2004) found the feasibility of spatial extrapolation of ecological status on the basis of land use in non monitored water bodies, which is of interest for the present study, to be an important question and crucial for the implementation of the WFD but recognized a strong gap of knowledge and scientific statements. Regardless of the knowledge gaps, the REBECCA project acknowledged that political decisions require spatially extensive understanding of the different problems (Garcia and Wasson, 2005).

Despite the efforts of the REBECCA project, the lack of methods linking human activities, i.e. pressures (evaluated through land cover), to ecological status at a large or even a regional scale within Europe was again pointed out by Wasson et al. (2010), who had mentioned the work of Donohue et al. (2006) in Ireland as the only exception.

Indeed, Donohue et al. (2006) had shown highly significant inverse associations between the ecological status of rivers and pressures like catchment urbanization, agricultural intensity and densities of humans and livestock. They had concluded that the likelihood of a river site being of good ecological status can be predicted with reasonable accuracy using simple models that utilize widely available land cover data, and they had reported respective land cover thresholds. Another work that relates ecological status to land use characteristics is the one of Villeneuve and Sarraza (2009) for the Seine-Normandie basin in France; this work presents a decision tree including several thresholds of pressure characteristics.

Relations between various pressure characteristics in a quantitative way, i.e. giving some kind of threshold, and general notions of “stream health”, “good stream condition”, “habitat quality and biotic integrity” or “macroinvertebrate response” are found more widely in the literature (Allan, 2004, Wang et al., 1997, Roy et al., 2003, Wasson et al., 2006). These works do not provide the relationships with ecological status as required by the WFD that are crucial for the present study, but they nevertheless provide valuable indicative values for comparison.

With respect to the most suitable spatial scale for elaborating relationships between land use pressures and river water quality, the respective literature review showed that pertinent studies give contradictory results, confirming the conclusions of Garcia et al. (2004); study results contradict to such an extent that Sliva and Dudley Williams (2001, p.3462) had identified an “ongoing dispute regarding whether the land use of the entire catchment or that of the riparian zone is more important in influencing the water quality, all other factors remaining constant”; in their own study, they found that “the catchment landscape characteristics appeared to have slightly greater influence on water quality than the 100m buffer”. In discussing the same issue, Frimpong et al. (2005, p.2) considered it an “unresolved question whether whole watershed or riparian land cover has a greater influence on streams and their biota”. In a more recent article, Zhou et al. (2012) conclude from their literature review that “studies have shown that land use pattern adjacent to a stream was a better predictor of water quality than the spatial pattern of the entire watershed, while others found that the proportions of land use types at the watershed scale better accounted for the variability in river water quality". On the same topic, Maillard and Pinheiro Santos (2008) pointed out that although using the whole of the watershed processes is valid, "the riparian zone has a disproportionate influence"; in their paper they had reviewed seven studies that had dealt with the issue and found that all but one had used the whole watershed as an input. In their own study, Maillard and Pinheiro Santos (2008) had applied different buffer widths and concluded that the differences between the subcatchment level, which they called ECZs (exclusive contribution zones), and the buffer level, which they called RZs (riparian zones), are generally small; they also conclude that "each WQ parameter can have a distinct pattern with relation to distance from stream".

Regarding suitable widths of buffers to be used, the literature was also found to be inconclusive. While Frimpong et al. (2005, p.1) state that "efforts have been made to optimise buffer dimensions incorporated into models, but none has explicitly determined a single optimum based on both longitudinal and lateral buffer dimensions", Lalande et al. (2012) arrive at the conclusion that "how wide the riparian zone must be in order to take into account all the processes involved between the river and its background, has not found a clear answer in the scientific community". Zhou et al. (2012) suggest buffers of different widths plus the subwatershed scale for different water quality parameters, while in a recent study, Van Looy et al. (2013, p.8) investigated two buffer widths (10m and 30m) and concluded that no consistent differences were observed in the responses for the different investigated buffer widths while. In summarizing the above variation in buffer widths, Allan (2004) stated that the so-called local reach is often described by a buffer of 100m to several hundred meters in width on each bank.

2.3 Involvement of stakeholders under the Water Framework Directive

The following part of the literature review aims to bring together the current scientific knowledge about consultation under the Water Framework Directive. I am aware that the consultation undertaken in the framework of this project refers to a specific technical component of the WFD only, while the term "consultation under the Water Framework Directive" generally is meant to refer to a much broader field of issues and in particular to issues that are considered to be of more obvious concern to, and have more direct impact on, stakeholders and the public. Nevertheless, this part of the literature survey is considered necessary because it sets the baseline for the DProf project with respect to the stakeholder consultation.

The citations in the literature review are from scientific papers except the references to the consultation process in Cyprus, which are from the official Cyprus report on the consultation results as approved by Cyprus authorities; thus, the perspective of the authors of the Cyprus' report is clearly different from the rest of the reviewed papers and the report's critique of the consultation process may be softer than of the respective processes in the other countries described in the scientific papers.

2.3.1 Importance of stakeholder involvement for the acceptance of proposed interventions

The literature in general considers that the involvement of stakeholders in decision making for environmental management is highly beneficial; a vast number of references to the topic exists and a few selected ones are quoted in the following lines. Stakeholder involvement was found to foster commitment to the process of sustainable development in general (Hage et al., 2010), to develop a greater sense of ownership of the solutions developed (Mostert et al., 2007) and to ensure the stakeholders' on-going involvement in the strategy (Cernesson et al., 2005). Pahl-Wostl et al. (2007, p.2) even go a step further and proclaim that "without taking into account stakeholders' information and perspectives and without their collaboration", integrated management approaches cannot be tackled. According to Lennox et al. (2011), decisions that have been formulated with public support are more likely to command assent and therefore lead to the desired outcomes while Muro et al. (2006) put forward that support for necessary measures will only develop when the interested parties can collaborate substantially in the development process of plans and measures. In the case that close cooperation of all relevant actors at the river basin scale cannot be achieved, this may lead to stakeholder groups becoming "united and unwilling to cooperate", ultimately causing strong conflicts (Slavíková and Jílková, 2011, p.12f). A specific outcome from a questionnaire survey by Blackstock et al. (2012) on the WFD participation process in Scotland seems to refer to this aspect: advisory group members who disagreed that the 'plan [the RBMP] can be accepted by wider stakeholders' felt that the responsible authorities needed to ensure that those expected to carry out measures were aware of and in agreement with the plans. This indicates the awareness of the advisory group members that dissent on the part of those stakeholders directly affected by measures would cause problems later on and, therefore, their agreement has to be sought before considering the RBMP "accepted by wider stakeholders".

Despite the numerous publications supporting the fact that involving stakeholders increases the quality and durability of decisions, this was doubted by Reed (2008) who points out that such claims have rarely been tested. He refers to growing disillusionment among environmental managers and conservationists because these claims did not materialize in practice and points to attempts of developing a more sensitive, post-participation approach to address these shortcomings. Thus, it seems that not the entire scientific community is convinced of the benefits of stakeholder involvement as the latter is commonly understood today. Still, the generally positive appraisal of stakeholder participation in environmental decision making clearly supports the stakeholder consultation envisaged in the framework of the DProf project.

2.3.2 Legal requirements for stakeholder involvement under the Water Framework Directive

The Water Framework Directive (European Parliament and European Council, 2000) is the "first EC legislation that forces the Member States to ensure public participation in policy-making" (van der Heijden et al., 2013, p.320). The involvement of stakeholders is referred to in Recitals no. 14 and 46 of the Preamble and in Article 14 of the WFD. Recital 14 introduces three ways of interaction with the public including users, namely information, consultation and involvement, while Recital 46 highlights the necessity to provide proper information to the general public to ensure participation. According to Article 14, water authorities shall "encourage the active involvement of all interested parties" and formal consultations of three documents must take place: the timetable and work programme, the interim overview of the significant water management issues and the draft version of the River Basin Management Plan (Slavíková and Jílková, 2011). As the changes proposed to result from the DProf project will have a clear impact on the river basin management plan, their consultation with stakeholders seems highly desirable thus supporting the stakeholder consultation proposed by the DProf project.

Consultations in the framework of the WFD must follow timelines that are strictly specified by the Directive while "consultation" is described by WFD CIS Guidance Document No.8 as the presentation of reports, scenarios or plans and subsequently asking people to comment, without conceding any share in decision-making (European Commission, 2003e). From the above it becomes clear that the different types of public engagement in WFD water management correspond to different degrees of legal compulsion (Benson et al., 2014): while the provision of information and the consultation on the three documents is obligatory, "active involvement" must be encouraged but may not necessarily occur (Russell, 2010).

In addition to the requirements for stakeholder involvement that stem from the WFD text itself, another obligation to ask for public comment on the Directive's implementation is in the framework of the Strategic Environmental Assessment to which all River Basin Management Plans must be subjected (Irvine and O'Brien, 2009).

In the Water Framework Directive, the requirements for the involvement of stakeholders are described in general terms only and the Directive draws on very broad understandings to define what its role should be (Steyaert and Ollivier, 2007). Questions like who participates and who does not or which mechanisms should be used are not specified (Papadopoulos & Warin, 2007, in Pares, 2011), and thus the Member States can organize the participation of stakeholders in their own way (Liefferink et al., 2011). However, with respect to who should participate it is, however, worthwhile to note that water authorities are not explicitly encouraged to involve the public in developing plans of measures (Benson et al., 2014) because Article 14(1) of the WFD refers to “all interested parties” and not to “the public”. The consultation of stakeholders only, as proposed in the framework of the DProf project, is therefore in line with the WFD requirements.

With respect to the transposition of Article 14 into national legislations, the Commission identified several Member States with serious shortcomings on the basis of a preliminary assessment in 2007 (Commission of the European Communities, 2007), while the study by De Stefano (2010, p.1338), which analyzed the situation in 20 European countries, concluded that “even the strict implementation of the WFD requirements might be insufficient to achieve good levels of stakeholder participation”. Similar conclusions are drawn by Howarth (2009, p.406) who identified the danger that “meeting the formalities of public participation in practice may be possible in a way that effectively defeats its purposes”. These statements hint to insufficient provisions in the Directive and lead to the conclusion that, at least in several Member States, it is highly probable that the poor transposition of an already inadequate European legislation will result in a poor stakeholder participation process.

2.3.3 Institutional setup

Suitable institutional arrangements as well as effective and efficient coordination between actors appear to be crucial for the implementation of the Directive. According to Nielsen et al. (2013), the Water Framework Directive requires integration of measures across a number of directives and a clear division of competencies is a prerequisite for effective coordination. Because many of the policies, plans and measures that must be put into action for the achievement of the WFD’s objectives exceed the powers of the water administration, the latter must promote and ensure cooperation (Hernández-Mora and Ballester, 2011) to accomplish the Directive’s objectives. Cooperation of various sectors and actors with their water protection agencies was recognized as needed for implementing water protection policy by central government agencies in Germany (BMU/UBA, 2005, in Moss, 2012). Such cooperation may be fostered by the presence of strong river-basin institutions, which was found to be an important factor to achieve stakeholder involvement in two of the cases studied by Mostert et al. (2007). In a study on the situation in Spain, Hernández-Mora and Ballester (2011) point to the need for effective inter-administrative coordination, but also to the coordination between different departments of the same administration, as a significant issue in water policy. For the DProf project the latter indicates the importance to bring the Governmental Departments and organizations involved in WFD implementation together in the stakeholder consultation.

The EU Member States have responded to the challenge of organizing the institutional setup for implementation of the WFD in different ways. The arrangements vary from an "iterative top-down/bottom-up process" in the Netherlands (Liefferink et al., 2011, p.716) to "rigid top-down and strongly hierarchical settings" in Greece (Zikos, 2010, p.1).

Institutional setup - centralization vs. decentralization

Despite the great variety, however, there seems to be a trend towards more centralization as implementation goes ahead. In the case of Denmark, Liefferink et al. (2011) reported an "increasingly centralised, state-led process" and in France the same authors found that an increasing degree of control over the process in the policy formulation phase is kept at the central level. In Germany, strengthening the powers of the federal government was recommended because "the state administrative structures are not compatible with effective and efficient management of surface waters in river basins" (SRU, 2004, in Moss, 2012, p.6). Based on their study of six countries around the Baltic Sea, Nielsen et al. (2013) concluded that the WFD, due to its complexity and relatively tight schedule pushes countries towards more centralised decision making processes. Still, while a high level of centralization is commonly interpreted as negative, it has advantages too. Especially in the first stages of implementation of the Directive it provided direction which was necessary to ensure timely implementation as well as equal conditions across river basin districts (Nielsen et al., 2013). The conclusions reported by Moss (2012) appear to support this argument by presenting the situation in Germany as a non-ideal example; they found that the considerable legislative and executive authority retained by the German federal states lead to major differences in how the WFD is implemented by the states, as well as to hugely increased coordination costs between the different actors. Findings from Poland by Nielsen et al. (2013) also highlight problems with a decentralized approach; in that country, the extensive dispersion of competencies inhibits a comprehensive operation of water management.

My work experience in Cyprus, a small country with highly centralized WFD implementation, supports these findings from the literature. In a small country with limited resources and a lack of e.g. research organizations or universities that could provide support in technical matters, centralized decision making without time consuming and cumbersome hierarchical processes allows quick implementation of e.g. monitoring techniques and also facilitates quick adjustments in case of initial failures or deficiencies; thus, in the Cyprus case the centralized institutional setup is an advantage and to some extent allows keeping pace with larger EU member states that can rely on more resources. Still, I recognize that this centralized approach keeps the WFD implementation distant from local stakeholders, e.g. communities, preventing them from being in continuous contact with matters of e.g. water quality of their local rivers. This lack of awareness of local stakeholders subsequently sets hurdles to e.g. implement measures needed to achieve the environmental objectives of the Directive.

It seems that, at least in the early implementation phase, central governments played “a crucial role in setting up a framework for integrated management across functionally linked policy areas” (Nielsen et al., 2013, p.442). In later phases of implementation however, a highly centralized approach may have negative effects. With respect to Denmark, Liefferink et al. (2011, p.720) fear that the downscaled stakeholder participation in the policy formulation phase may “backfire in the phase of practical implementation by the municipalities”. In the case of France, the same authors found that because the institutions at river basin level are operating on a geographically rather large scale, local conflicts will come into play in the implementation phase. These anticipated problems correspond to results from empirical analyses by Zikos (2010) that pointed to the general problem of centralized and rigid bureaucratic systems that impede social learning; the latter is interpreted in the sense of Pahl-Wostl et al. (2007), i.e. dealing effectively with differences in perspective among stakeholders, solving conflicts, making and implementing collective decisions, all of which are crucial processes for successfully implementing the Directive at the regional and local level. The above findings seem to confirm that for successful implementation there must be a “trade-off between a strong central government keeping implementation on track and ensuring some coordination and a multi-level structure ensuring the best fit of each RBMP” (Nielsen et al., 2013, p.442), where the multi-level structure should be adapted to each country’s specific characteristics (physical and administrative) but should always reach the crucial local level.

2.3.4 Scale issues

The importance of scale in participation and consultation processes has long been recognized and was included e.g. in the “Rio Declaration of 27 principles of sustainable development” (United Nations Conference on Environment and Development, 1992) which stressed that participation processes on environmental issues should be handled “at the relevant level”. The WFD text also clearly recognizes the significance of scale: “The success of this Directive relies on close cooperation and coherent action at Community, Member State and local level” (European Parliament and European Council, 2000 Preamble 14). The above highlight two important issues of scale: First, each environmental issue has to be matched to the most suitable policy level for greatest possible participation success and second, coordination and integration between different levels of management is crucial to ensure coherent and comparable achievement of the Directive's objectives across all policy levels. As far as the most suitable policy level is concerned, Muro et al. (2006) consider public participation to be most effective on a smaller scale; processes at that scale also satisfy the criteria for success put forward by Woods (2008) namely that the public can relate to the boundaries, scale and local nature of the issues. Similar advantages of local scale projects are advocated by Russell (2010) who supports that the engagement in and discussion of local issues by stakeholders leads to higher public interest and promotes the generation of ownership of the process. The above are confirmed by findings from the Cyprus consultation process (Karavokyris & Partners Consulting Engineers S.A. and Kaimaki, 2011c) where the stakeholder group meetings at regional (District) level were generally regarded an exceptional success because the participants had first-hand knowledge of the problems and had the opportunity to exchange views on these practical problems; it is interesting to note that for the corresponding national level consultation meeting, there is no mention to what extent it was a success or not. With respect to coordination and integration, Mostert et al. (2007) concluded from their case studies that stakeholders in river-basin management operate at different spatial scales and have different areas of interest and they identified integration across different scales and policy domains as a major challenge.

With respect to problems and lack of integration between different management levels, Zikos (2010) reported from Greece that performance at Pilot River Basin level was poor but that some important developments had taken place at the sub-regional level, indicating insufficient cooperation between the two levels but also the potential of the lower level to achieve progress on its own. The discrepancy between the sub-basin level and the basin level was recognized by Hernández-Mora and Ballester (2011) and they highlighted the need for integration of the participation processes that take place at the local level into the management at the basin level. Such integration was seemingly not undertaken in England and Wales, because Benson et al. (2014) expressed complaints that the participation process had only marginally influenced plan production and that planning reflected over-riding national objectives that had followed a pre-designed agenda. Similarly, a discrepancy between the strategic visions of public authorities and the concrete initiatives that the local stakeholders were concerned about was identified by Mostert et al. (2007) in one of their case studies. A concrete example is given in another case study of the same authors, where the scale of flood alleviation measure development, which took place at the basin scale, was found too far from the local interests of some stakeholders. Such situations were generally described by Russell (2010, p.3) by saying that “often the lowest scale of EU water planning is the river basin which is often too large for the localised concerns of the general public or civil society”.

Several authors have discussed ways how to accomplish the integration between the different policy and management levels. For example, Moss (2012, p.2) mentions the “common practice of shifting management of environmental resources to a higher level in order to cover the larger spatial scope of a problem” but also admits that this often leads to higher transaction costs. Bridging organizations that would link the macro level of WFD implementation to the micro level are suggested by Pahl-Wostl et al. (2007) while Russell (2010, p.11) takes a more practical approach and proposed pilot projects at the local level to achieve “quick wins” and the subsequent up-scaling of locally suitable approaches; in a very similar way Muro et al. (2006) have stated that processes that start on a smaller scale need subsequently to be aggregated to a higher scale. An interesting system was reported by van der Heijden et al. (2013) from the Netherlands. The so-called convergent planning was introduced as a cyclic time frame to meet the deadlines of the WFD: for three consecutive years, in the first half of each year, decisions would be made at the (sub-)river basin level; in the second half of each year, decisions would be made at a national level, and so on; such an approach very much resembles action research cycles.

Concluding, it seems clear that there is ample room for improvement of the cooperation across scales in several EU countries and that the suggested solutions refer to the importance of the local scale and also to the establishment of arrangements that could act as a bridge between the various levels and would thus achieve an integrated policy implementation across the entire scale encompassed by the WFD.

2.3.5 Cooperation beyond water authorities, across sectors and directives

With respect to the formal organization of the required cooperation and coordination between the various stakeholders, Mostert et al. (2007) investigated 10 case studies in various European countries and found that in most cases, stakeholder fora or other platforms were established to allow interaction among the different stakeholders; Irvine and O’Brien (2009) report the establishment of forums for this purpose in Ireland and thus add another case to the study of Mostert et al. (2007). In Denmark, stakeholder groups consisting of the governmental authorities and the relevant organizations in the fields of agriculture, nature conservation and environment were established, while in France the focal points for formal stakeholder involvement in water management is the basin committee. Its members include the civil society, market actors including agricultural organizations, local government and state representatives. In the Netherlands, the key role was assigned to the water boards at the sub-river basin level. While the more centralized arrangements in Denmark and France appear to ensure cross-sector cooperation, the water boards’ limited say over other policy sectors seems to limit the potential for cooperation across policy areas in the Netherlands (Liefferink et al., 2011). Independently from the chosen structure of the fora or platforms for interaction between stakeholders, Pahl-Wostl et al. (2007) suggest that such collaborative platforms may become de facto a permanent part of the governance structure and they highlight the platforms' ability to bridge established boundaries between involved stakeholders and their importance for implementing and supporting integrated and sustainable resource management over extended periods of time.

2.3.6 Practical implementation

In the literature on public consultation in the framework of the WFD, many different formats of consultation are mentioned. In England and Wales, Benson et al. (2014) reported that public hearings, drop-in surgeries, public and sectoral workshops, liaison panels and issue group meetings or workshops were organized while in Spain there were separate workshops for each stakeholder category, multi-stakeholder workshops, basin-wide expert workshops, participatory processes for specific users and thematic basin-wide workshops and plenary presentations (Hernández-Mora and Ballester, 2011). In Ireland, the main forums for stakeholder consultation were the advisory councils (Irvine and O'Brien, 2009) and Moss (2012) in a case study in a specific basin in Germany report that round tables, workshops and working groups on areas requiring priority attention were implemented. In the Czech Republic seminars for the public and/or stakeholders were held (Slavíková and Jílková, 2011) and Russell (2010) reports to have used public outreach events in Romania. In Cyprus, open public discussions were held at regional (district) and national level; these included open public meetings, stakeholder meetings and community leader meetings (Karavokyris & Partners Consulting Engineers S.A. and Kaimaki, 2011c). Still, the seemingly great variety may in the end only be a great variety of names. A closer look indicates that very similar consultation events may just have been named differently in different Member States and by different authors, while the mentioned types refer in most cases to some form of stakeholder fora or platforms that had been termed generically as "consultative panels" by Finch and Lewis (2003, p.173). Such panels are being conducted in different forms and involve drawing people together in sessions to deliberate, to contribute to decision-making particularly in more unfamiliar, technical or complex areas (Finch and Lewis, 2003) and to allow interaction among the different stakeholders (Mostert et al., 2007) . The above references from the literature indicate that the important point is to establish a space where stakeholders can meet, discuss and deliberate without giving too much emphasis on the name of this "space"; in that respect, the stakeholder consultation of the DProf project can also be seen as such a "space" for stakeholders to meet, discuss and deliberate about the changes proposed by the technical part of the project.

As it was pointed out above, the WFD does not explicitly encourage the member states' water authorities to involve the public. As a result, in England and Wales in 2008 no formal arrangements had been made to engage the public at the local level (Woods, 2008, Howarth, 2009) and the situation was found to be the same several years later when the non-organised 'public' was still without representation in the process (Benson et al., 2014); the latter authors report that the focus of the process was generally on stakeholder engagement while all interviewees in their study "questioned the lack of genuine public or community representation in the panels" (Benson et al., 2014, p.16). In a similar manner, Karavokyris & Partners Consulting Engineers S.A. and Kaimaki (2011c) complained about the lack of presence of the public in the Cyprus consultation meetings. In Catalonia a consultative mechanism was established that is, however, not open to non-organized citizens and even organized groups have to be appointed for membership by the government (Pares, 2011). Still, an approach with focus on stakeholders seems not uncommon in environmental matters because "for purposes of efficiency … most conservationists focus on engaging those who hold a stake ... rather than attempting to meaningfully engage with the wider public" (Reed, 2008, p.2418). On the other hand, there are examples from WFD implementation where efforts were made to go beyond legal obligations and promote active public participation processes. In the autonomous communities of Cantabria and Navarra in Spain, water debates were extended beyond traditional stakeholders and this involvement of the wider public was considered a success in both cases (Hernández-Mora and Ballester, 2011). Still, the topic of the DProf project is considered much too technical to consider an involvement of the wider public.

Several authors have referred to difficulties in practically applying participation methods described in the literature. According to Hage et al. (2010, p.262) the participation literature is characterized by "rather theoretical ambitions" that must be put into practice by real-life projects, while Howarth (2009, p.391) found that in WFD implementation, "incongruities between the ideals underlying public engagement and the realities of applying complex environmental legislation are evident". Russell (2010) found in a project in Romania that the participation approach proposed in the guidance document was very complex and the competent authority did not use the document in practice while Zikos (2010), in a project in Greece, experienced a considerable difference between organising a participatory process in reality and the theory of participation and the WFD guiding documents. It is interesting to notice that both latter examples are from south-eastern Europe, while no such examples of difficulties were found in papers that describe the situation in middle or northern European countries. Still, the findings by Russell (2010) and Zikos (2010) agree with the conclusion of De Stefano (2010) that at the beginning of the WFD implementation process, public participation in water management was poor or very poor especially in Southern and Eastern Europe. As

Cyprus is the South-Easternmost EU member state, the latter has special relevance to the DProf project and warrants that the stakeholder consultation may become a difficult undertaking.

With respect to the timing of stakeholder involvement, there is agreement that they should be engaged as early as possible. In his review of “Stakeholder participation for environmental management”, Reed (2008) makes reference to several authors and concludes that for high quality and durable decisions, stakeholder engagement should start as early as possible in the decision-making. Lennox et al. (2011) have identified increasing recognition by governments that early involvement of the community in the process may avoid disagreements and conflict in later stages while De Stefano (2010) points out that in all the 23 European countries/regions included in her study there is a need for earlier involvement in water management processes. There is agreement in the literature that early engagement is beneficial for consultation processes and such an approach may, if possible, be adopted for the DProf consultation process too.

The literature includes several recommendations for the initial phase of participation processes. Pahl-Wostl et al. (2007, p.8) highlight the importance to explicitly discuss and establish the ground rules for interaction, as this “promotes joint ownership of a process and may reveal in an early stage potential sources of disagreement and conflict” while Hernández-Mora and Ballester (2011) mention that in the processes organized by the Catalan Water Authority in Spain, each process started with a shared diagnosis of the situation; similarly, the process in Greece described by Zikos (2010) started with an initial mapping of the water problems and the water governance structure. The latter examples are considered important for the DProf consultation and will as much as possible be adopted, i.e. it will be tried to establish a common baseline for all in the beginning of the consultation events.

The building of capacity of the water stakeholders for their active participation in decision-making and meaningful engagement in the process has been identified as an issue, and this may include provision of adequate information, as well as training (De Stefano, 2010) and education for highly technical decisions (Reed, 2008). While the provision of adequate information seems feasible for the DProf project, training and education of the stakeholders is clearly out of the scope of the present study.

Practical implementation - communication of information, highly technical information, and stakeholder capacity

Information is fundamental for effective public participation (Hernández-Mora and Ballester, 2011) and the dissemination of technical information and its discussion among stakeholders is a necessity for catchment management (Irvine and O’Brien, 2009). However, a number of shortcomings have been identified in the information provision processes for implementation of the WFD in the EU Member States. In the Czech Republic the structure of the information was found to be a big problem (Slavíková and Jílková, 2011) while De Stefano (2010) criticized that the material was bulky or unorganized and that this discouraged involvement and consultation of stakeholders. An issue that is brought up by numerous authors is the technical nature of the planning documents and the overly technical and legal language that was used in the EU Member States they studied (Benson et al., 2014, Blackstock et al., 2012, Hernández-Mora and Ballester, 2011, Slavíková and Jílková, 2011, van der Heijden and ten Heuvelhof, 2012). In that respect, Howarth (2009) recognizes the complex scientific or technical methodological contexts of many issues to be resolved in implementing the WFD and concludes that this may lead to marginalising participants from outside a narrow community of expert stakeholders. Still, these circumstances do not keep stakeholders from being interested in technical issues, judging from the complaints of Hernández-Mora and Ballester (2011, p.16) that “it is often difficult to find rigorous technical information that is presented in a user-friendly and synthetic format” and by Irvine and O’Brien (2009, p.370) that “technical information was limited to a series of general summaries”. Still, the technical nature of the documents and the focus on technical aspects, rather than on communication, were considered a barrier to public participation and social learning (Hernández-Mora and Ballester, 2011, Mostert et al., 2007). As a result, stakeholders had problems in developing opinions (Benson et al., 2014) and were often “too busy trying to understand the information to truly deliberate” (Blackstock et al., 2012, p.118). The above show clearly that the information was too technical to be understood by some of the interested parties, as was pointed out by De Stefano (2010), who however goes beyond blaming only the information provided by the authorities and also mentions the limited capacity of the participants and characterizes this as a major impediment for effective stakeholder participation.

To address and overcome the above deficiencies, easy-to-read information is needed to inform the public of the technical issues (Russell, 2010), the “digestibility” of the information should be improved and it is necessary to work on building the capacity of water stakeholders (De Stefano, 2010, p.1336). Some authors also make reference to tools that could help to improve the consultation and participation processes in the framework of the WFD. Smith et al. (2013, p.87) mention maps as a means of helping the Scottish authorities to communicate complex environmental information, and refer to “the idea that the maps might establish one ‘version of the truth’ consistent with the role of a boundary object – establishing common understanding between different groups of actors” while Russell (2010) describes tools which, in addition to participatory research methods, utilize e.g. GIS and river basin conceptualization methods to stimulate stakeholder discussions; the author must have realized that these tools are rather technical as can be seen from the main caveat Russell mentions himself: the public needs to understand the issues.

The issue of rather technical subjects clearly applies to the case of the DProf project and needs to be addressed in the best possible way to ensure that the stakeholders understand the issues at hand and can contribute to the process. Still, the tight timeframe of the project does certainly not allow building the capacity of water stakeholders (De Stefano, 2010) or providing for specific education (Reed, 2008).

<u>Problems and limitations of stakeholder involvement posed by lack of stakeholder concern and awareness for WFD issues</u>

While on the one hand the WFD prescribes consultation as obligatory, several authors have found a lack of interest on the side of the public and the stakeholders. The experiences of Benson et al. (2014) from interviews with stakeholders in England and Wales suggest a lack of interest in water-related questions, while Slavíková and Jílková (2011) report that some of the stakeholders called upon in the Czech Republic did ignore the appeals and as a result not all relevant interests are included in water planning. In the Netherlands the citizens were given the opportunity to join the process and to visit meetings but only a few did (van der Heijden et al., 2013). These findings agree with the ones of Irvine and O'Brien (2009) who found the Irish public to be detached from WFD issues and with limited understanding or regard for the relevance of environmental protection and they also agree with the findings of van der Heijden and ten Heuvelhof (2012) who concluded from interviews that Dutch citizens are not interested in complex water issues. However, the latter authors conclude further that, while citizens do not see the need to participate actively in environmental issues as long as they do not directly affect them, they start caring about such issues once they are implemented and impact on them. In that respect, the findings of Koontz (2005) seem relevant; in a study on farmland preservation in Ohio, U.S., he found the level of concern of the community for the issue to be related to the achieved level of policy change, where counties with high community concern showed a high county policy change, indicating that if people are concerned by an issue, they also become involved and succeed to influence policy. The above findings are somewhat discouraging for the DProf project; it is clear that issues without direct and clearly recognizable impact on stakeholders do hardly raise their interest, and because the DProf topics of river typology and water bodies are dealt with at the national scale and local impacts are hardly foreseeable within the project, stakeholder interest may be reduced.

The issue of provision of adequate information to the public is also of importance in the above context, because a lack of communicating the relevance of the process to some sectors' interests may result in these sectors being difficult to reach (Mostert et al., 2007) or the public being not conscious of their stake in the issue (Russell, 2010). A situation where, due to lack of information, actors hadn't realized their potential role in the implementation of the Water Framework Directive was also identified by Zikos (2010, p.12) at the beginning of his research project in Greece and he mentions "a futile attempt to open a discussion on the WFD but soon we noticed that none of the participants were aware of the directive". Still, an interpretation of this specific case needs to take into account that the incident took place in 2004 only four years after the Directive came into force. On the other hand however, it must be noted that the area of study was one of the "Pilot River Basins" where WFD implementation had been "tested" since 2002.

<u>Problems and limitations of stakeholder involvement posed by insufficient stakeholder opportunity to influence</u>

While above it was shown that it might be difficult to involve all significant stakeholders, another issue is whether the stakeholders that join the process are able to really influence the water management decisions that are taken in the end. Experiences from several authors show that this level of engagement is sometimes quite low. In Ireland the members of the advisory councils had no clarity what they can and cannot influence (Irvine and O'Brien, 2009) and in the Netherlands, van der Heijden et al. (2013) found that citizens were hardly involved in the process while stakeholders do not see their input reflected in policy and they, therefore, consider public participation a failure. A similar situation was reported by Slavíková and Jílková (2011) from the Czech Republic where possible influence on real decision-making was defined very poorly and as a result the public, including the stakeholders, believed that their participation cannot really change something. Mostert et al. (2007) also emphasize the need for clarity about the role of stakeholder involvement but they also pointed out that a lack of decision-making powers of the organizers of the consultation and/or participation process leads to doubts of the stakeholders whether their input would make any difference. Pares (2011) studied the "Commission for the Sustainability of the Ebro Lands" that had been created as a new space of public participation in Catalonia and found that, while this new participatory mechanism is recognized by all stakeholders as a space where all voices are equally heard, there is still a deep uncertainty about the real impact on the policy-making process; while the concrete actions that should be carried forward are produced through innovative mechanisms of deliberation, they are subsequently transferred to the corresponding structure of the government that will decide if these actions will be implemented or not. It should be noted however, that such a process conforms to the WFD's legal requirement for "consultation" that does not transfer the actual decision-making to the stakeholders but only requires their positions to be heard. In any case, the high degree of consensus that has been achieved in the proposals of the commission puts strong pressure on those who should implement these actions (Pares, 2011).

With respect to the stakeholder's opportunity to influence WFD implementation, it is also important to keep in mind that the environmental goals are set in reference to undisturbed conditions and, consequently, the setting of management objectives is not foreseen to be done through the public consultation. This fact was criticised by Blackstock et al. (2012) who complained that Scotland's advisory groups members were not given the opportunity to set objectives or change classification results and also by Steyaert and Ollivier (2007, p.12) who found that through the fixed standard of good ecological status, "the WFD leaves little space for stakeholders to commit themselves to the political purposes".

One of the few optimistic conclusions on stakeholder's opportunity to influence was made by Zikos (2010, p.14) based on his case study in Greece who noted that, while "the participatory process that took place was a concept completely alien to the region's social norms", the local actors realised that through participation even institutionally weak stakeholders can influence a process.

With respect to the DProf project, the above clearly show the importance to inform the participants to what extent they can influence the final outcome of the discussed topics, within the normative and technical constraints set by the Directive.

Problems and limitations of stakeholder involvement posed by limitations of time and of resources

In the literature on participation and consultation processes in the framework of WFD implementation there is a broad agreement that such processes take time; in that respect, Hernández-Mora and Ballester (2011) pointed out that it is necessary to grant participation processes sufficient time for the emergence of potential conflicts and their resolution. In the same sense, Mostert et al. (2007) suggested that the stakeholders need to enter into a long-term working relationship and Irvine and O'Brien (2009) pointed out the requirement for ongoing and diverse discussion. These recommendations are also related to the preferable early involvement of stakeholders that was discussed further above. While Irvine and O'Brien (2009) generally characterized stakeholder consultation for WFD purposes as complex and time consuming, Mostert et al. (2007, p.13) put forward that "social learning really becomes an issue in complex organizational settings and in controversial cases" and that in such case the processes would become time consuming and costly. The situation was summarized by Subirats (1997, in Hernández-Mora and Ballester, 2011, p.2) who stated that "incorporating public participation implies delaying the decision making process" in order to obtain socially feasible results. For the above reasons, Cernesson et al. (2005, p.4) suggested that "social learning processes should only be embarked upon for issues that are important for the stakeholders, not for relatively minor issues".

The WFD has provided a strict time frame to which the Member States must adhere to (van der Heijden et al., 2013). This affects also participation and consultation and the different deadlines put an external time pressure on the process (Cernesson et al., 2005). Under these circumstances it is no surprise that the participation and consultation mechanisms were said to be time limited (Pares, 2011), that the WFD timetable was found to have 'too tight a timescale' and did not provide sufficient time for full deliberation on all the issues (Blackstock et al., 2012, p.117). It has also been reported that stakeholder groups could not meet often enough to make any real progress (Mostert et al., 2007) and the Ribble WFD pilot project concluded "that time constraints upon the project were a significant limiting factor" (Howarth, 2009, p.409). Participants of a regional meeting in Cyprus commented that there was too little time for the detailed presentation of all the issues and measures (Karavokyris & Partners Consulting Engineers S.A. and Kaimaki, 2011c). In the words of Catalan social activist Josep Grau (Pares, 2011, p.470): "The participatory system required a great amount of time and we didn't have it". However, the time limitations also lead to inequalities of opportunities to participate. As Pares (2011) found in Spain, social organizations and citizens were very limited especially in time availability, while economic agents generally have more time to take part. In addition, van der Heijden et al. (2013) report from the Netherlands that the pressure of timing caused a tension between timeliness and thoroughness and that this seems to have impacted on the choices made; these choices were afterwards looked back on with criticism.

The time pressure makes it a challenge to balance the requirement for genuine democratic input with the need to take effective and timely management decisions (Benson et al., 2014). Authorities' response to this challenge is mostly to limit participation and consultation and as a result it is often undertaken as "a mere formality without sufficient time or integration within the decision-making process" (Hernández-Mora and Ballester, 2011, p.17) or it may lead to "technocratic public participation" as it was observed in the Netherlands by van der Heijden et al. (2013, p.320). In the Czech Republic, Slavíková and Jílková (2011) found that authorities are afraid of extreme opinions which could slow down or block the planning process and in response they compromise between encouragement and limiting the role of stakeholders. In a Pilot River Basin Project in Greece, public consultation and participation by local stakeholders and NGOs were first seen as key requirements for the successful implementation of the project by the responsible Ministry. However, later the original position was reconsidered because public participation may "complicate negotiations and participatory processes could take a lot of time and money" (Zikos, 2010, p.8). For the Netherlands a similar experience was reported by van der Heijden et al. (2013, p.329)**:** "At first we aimed for a very democratic and collaborative process. Yet, this took too many meetings. Over time the strategy was changed."

In terms of available time, the DProf project is very similar to the situations described in the literature above because the project is embedded in the implementation of the WFD in Cyprus and thus has to be aligned to the deadlines of the Directive, in this case the preparation of the second Cyprus river basin management plan. Therefore, time for the conduction of the project is limited and it is anticipated that this time constraint may entail problems and shortcomings

Recognizing that the public participation process is one of the most time consuming steps in implementing the WFD, Russell (2010) suspected that this may reflect a deficit in institutional capacity to conduct effective public participation. This would indicate a lack of resources and such a reasoning is supported by Hernández-Mora and Ballester (2011) who found from their study in Spain that insufficient human and financial resources are given to public participation, as a result of the failure of responsible bodies to acknowledge the relevance and usefulness of public participation. The evaluation of the consultation process in Ireland lead Irvine and O'Brien (2009, p.370) to similar results and they mention "insufficient resources invested in the public-participation exercise" as one of four possibilities for the poor public response. But also the stakeholders face problems of limited resources. In her study including 20 European countries, De Stefano (2010) found that in several countries the NGOs face big problems in coping with WFD consultation processes because of their limited financial and human resources while Mostert et al. (2007) mention limited resources as important hindering factors for both the organizers and other stakeholders. As a solution to resource problems, the latter authors suggest to deploy processes designed to make limited demands on the stakeholders but also financial and other support to be provided for some stakeholders.

Apart from a general lack of resources, a lack of experts with suitable expertise may also be an issue. In that respect, Hernández-Mora and Ballester (2011) mention a scarcity, in Spain, of professionals specialized in public participation and particularly in the water management and ecosystem sectors. Considering that Spain is one of the larger EU countries this hints at an even greater lack of such specialists in smaller EU countries and especially in the Southern EU where public participation implementation lacks behind Western European or Scandinavian countries. In that respect it is interesting to note that in Cyprus, an educational consultation techniques workshop was held for public officers in the early phase of the consultation process (Karavokyris & Partners Consulting Engineers S.A. and Kaimaki, 2011c).

Chapter 3. Methodology and project activity

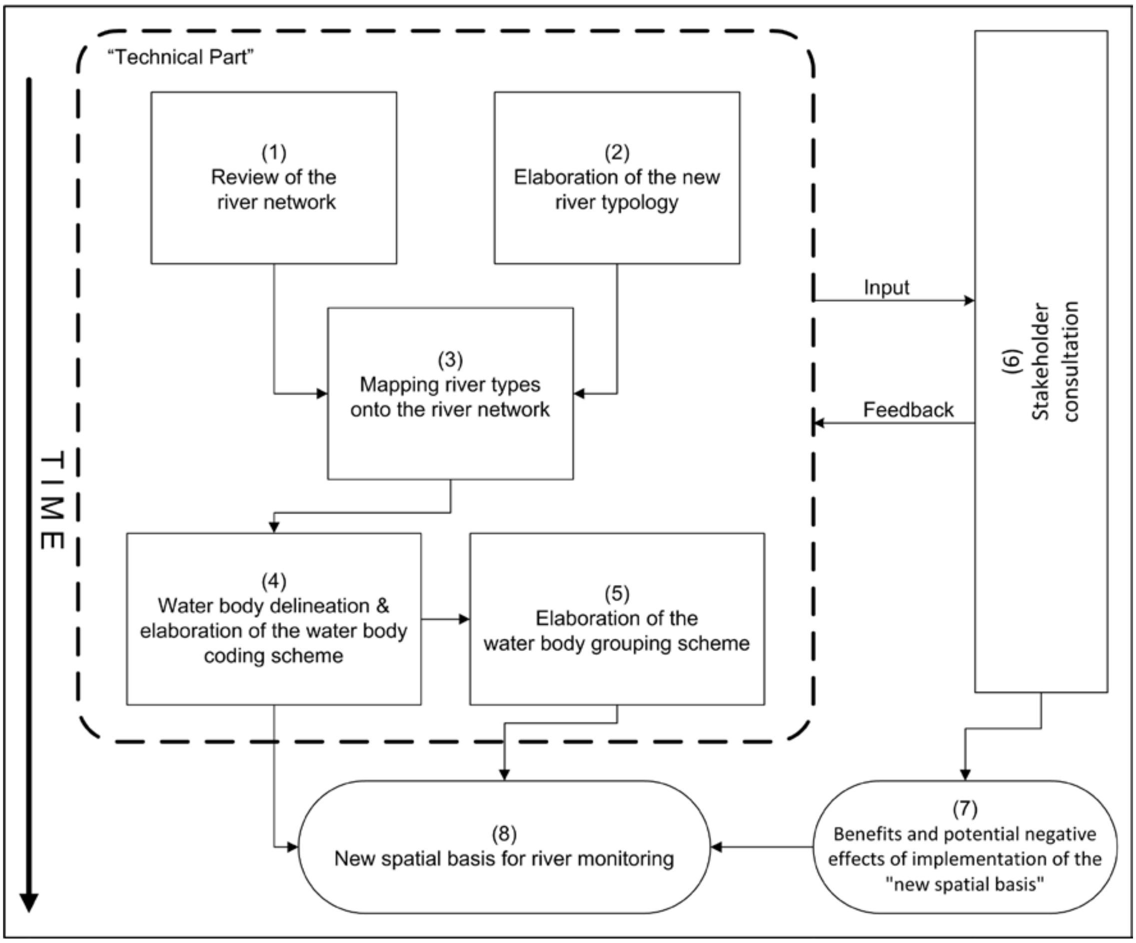
As it was mentioned already in Chapter 1.2 above, the DProf project consists of several “building blocks” or components. A more detailed consideration of the project’s objectives leads to the identification of the following components of the project:

1. Review of the Cyprus river network, determination of rivers and river sections to be considered in the analysis (based on e.g. size limits).
2. Establishment of a new typology for Cyprus rivers, based on their hydrological regime, as determined from their stream flow characteristics.
3. Mapping of the new river types, i.e. the application of the river types to the river network.
4. Delineation of river water bodies based on the new typologically classified river network and on pressures.
5. Elaboration of a grouping scheme of river water bodies, taking into account the pressures acting on the rivers and catchments, which will contribute to improved water status assessment procedures for unmonitored water bodies
6. Collection of information from major stakeholders on anticipated benefits and potential negative effects of the proposed new river water bodies network.

From the above it becomes clear that the project involves technical aspects as well as “people-related” aspects (Middlesex University, 2011) and this fact had to be taken into account for the development of the project methodology by selecting appropriate approaches for each aspect. The components 1-5 above, which correspond to the technical part of the project, have interdependencies between them and they need to be implemented in a sequential order. Component 6, which will in the following be termed “stakeholder consultation”, is proposed to run in parallel with the technical part and provide input to it, as is illustrated in Figure 1 below.

Before starting to actually develop the methodological approach to the project, it was necessary to consider the general “boundary conditions” into which the proposed work is embedded. As was described before, the project aims to investigate shortcomings of the implementation of the Water Framework Directive 2000/60/EC (WFD) in rivers in Cyprus and to elaborate recommendations to rectify them, and to investigate the benefits and potential negative effects of the implementation of the proposed recommendations. Hence, the recommendations of the project have to comply with the requirements of the WFD and, consequently, the methodology to be applied is constrained by the WFD's prescriptions for river typologies, pressures acting on water bodies and biological quality elements. Following the view of Rhoads and Wilson (2010, p.27) that inquiry can be "viewed as the interplay between theory and observation" and that "the comparison of observational information with theoretical ideas constitutes the core of scientific inquiry and represents the process by which scientific knowledge is generated", it becomes clear that in the case of the present project, the WFD text does to a large extent predefine the above "interplay between theory and observation" by specifying the rules for establishing river typologies and it is, therefore, the main "boundary condition" of the project. Further constraints will be elaborated in the following sections.

Figure 1: DProf Project components, activities and timeline



In the following description, the "technical part" and the stakeholder consultation will be dealt with separately, one after the other, because of the methodological differences between them. For each component, a structured approach is taken as suggested in the DPS 4561 handbook (Middlesex University, 2011) discussing the methodology in terms of perspective, methodology, methods, data etc. In addition to the suggestions of the DPS 4561 handbook (Middlesex University, 2011), issues like the identified relevant research questions, constraints and the practical framework are discussed.

3.1 Development of the new spatial basis for river monitoring and management - technical part of the DProf project

3.1.1 Perspective – Approach - Constraints

This technical part of the project draws on my post-positivist natural science perspective that takes, as it was pointed out in chapter 1.1.5 above, an empiricist-inductive objectivist approach. The hydrological paradigm to be applied in the DProf corresponds to considerable extent to the one described by Beven (1987) who discussed the hydrological paradigm and stated that "theoretical development proceeds by inductive generalization from a body of observations into a formal structure capable of deductive prediction of further events". In the case of the present project, the observations are stream flow data from certain points along Cyprus rivers, and "inductive generalization" of these, using as main tool statistical methods, have led to the "formal structure" of a river typology. The mapping of this typology allowed depicting the flow regimes longitudinally along the rivers.

The approach taken was a post-positivist one, considering the created knowledge as the best available, which however is potentially subject to amendment (Middlesex University, 2011).

The constraints, or the practical framework, of the "technical part" of the project are given by the WFD itself as well as by the related WFD CIS Guidance Documents (e.g., European Commission, 2003a, European Commission, 2003b, European Commission, 2003c, European Commission, 2003d). In addition to these general constraints more specific ones are mentioned in the following chapters.

Each of the components in Figure 1 is discussed below following the structure suggested in the DPS 4561 handbook (Middlesex University, 2011) by addressing, where appropriate, specific issues of perspective, approach, constraints and methodology.

3.1.2 Review of the river network

Methodological considerations

For the sub-component (1) "Review of the river network", the relevant research question is "What are the 'appropriate' or 'correct' rivers to be considered for WFD implementation in Cyprus?" This question targets issues like the minimum catchment size or river length for a river to be taken into account but also considerations like the significance of a stream with respect to ecology or water use.

The constraints for this sub-component are the WFD text itself as well as the related WFD CIS Guidance Documents. In addition, specific comments from the European Commission (COMM) on the first Cyprus River Basin Management Plan (European Commission, 2012) had to be taken into account.

The applied methodology employed a two-step procedure: information gathering from the literature and from my personal experience was followed by application of the findings to Cyprus watercourses.

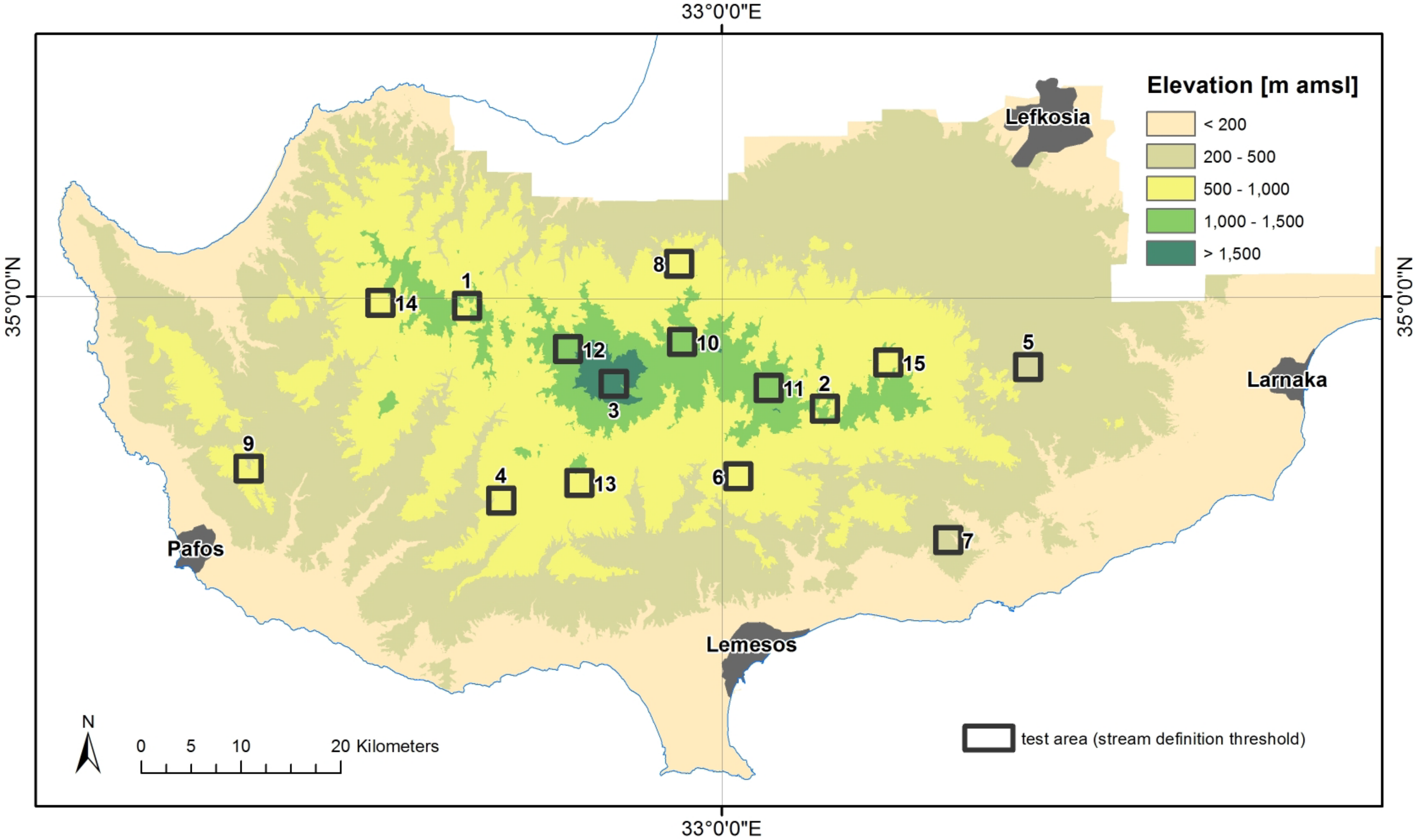
Implementation – project activity

The rivers and streams to be included as WFD water bodies were selected from a stream network that had been purposely created by computer-assisted stream definition from a Digital Elevation Model (DEM). I considered this step necessary because a topologically consistent stream network, with geometric-hydrologic characteristics for each stream segment, was required to allow the water systems identification according to WFD Annex II be based on consistent and quantitative criteria, down to the level of small stream segments; this was considered crucial to justify the planned deletion of certain small water bodies. Such a stream network was not available and, therefore, it had to be created. The methodology of its creation is described in the following paragraphs.

A DEM with 5m grid size was available at the geodatabase of the WDD and this was used as a basis. To make the GIS operations feasible in terms of file size, this DEM was generalized into a DEM of 20m grid size. Rivers of stream order equal to or greater of five, according to Strahler's (1957) stream ordering method, and some selected smaller order streams in certain flat areas were then "burnt" into the DEM using the ArcGIS "DEM Reconditioning" tool. The GIS layer of the streams with the stream orders had been digitized in the past from 1:50.000 topographical maps (Directorate of Military Survey, 1972) and was available in the WDD geodatabase.

The stream definition threshold was determined from stream starting points (channel heads) that were identified on topographical maps of the K717 series of scale 1:50.000 (Directorate of Military Survey, 1972). This map series of Cyprus is acknowledged locally for its detail, accuracy and consistency – facts that I had myself verified with field observations, on several occasions. The use of maps of scale 1:50.000 is supported by Souchon et al. (2000) who had considered this scale an "acceptable compromise" when they undertook the WFD characterisation work in Southern France. While I acknowledged that "acquisition of even limited field data is recommended" (Montgomery and Foufoula-Georgiou, 1993, p.3925) for estimation of the stream definition threshold, this was not possible within the timescale of the DProf project.

Figure 2: Test areas for stream definition threshold determination



A flow accumulation grid (20m x 20m grid size) was created based on a DEM available in the WDD geodatabase. Fifteen (15) test areas were distributed over Cyprus, mainly in the Troodos mountains, where most Cyprus rivers originate, and with a focus on headwater areas close to the water divide, i.e. the very areas where the channel heads are located (Figure 2).

Each test area has an extent of 2.5 x 2.5km, i.e. it has an area of 6.25km^2. In the 15 test areas, a total of 634 channel heads were identified and digitized. In each case, the finally digitized channel head was identified as the closest pixel to the corresponding channel head of the topographical map that, "based on its flow accumulation area, could realistically be considered the intended channel head location" (Elmore et al., 2013, p.4). The catchment areas at the digitized channel heads, i.e. the number of flow accumulation pixels draining through each channel head pixel, were extracted from the flow accumulation grid.

In Figure 3 the elevation of the digitized channel heads is graphed against their flow accumulation values (the number of pixels draining through each point, with a grid size of 20m x 20m). Note that the digitized channel heads cover a wide range of elevation, even though the test areas had been placed with a focus on headwater areas. From Figure 3 one can see that, while few outliers are observed, there is apparently no relation between elevation and flow accumulation, i.e. the contributing catchment area.

Figure 3: Stream start points (channel heads) mapped from 1:50.000 topographical map. Elevation vs. flow accumulation.

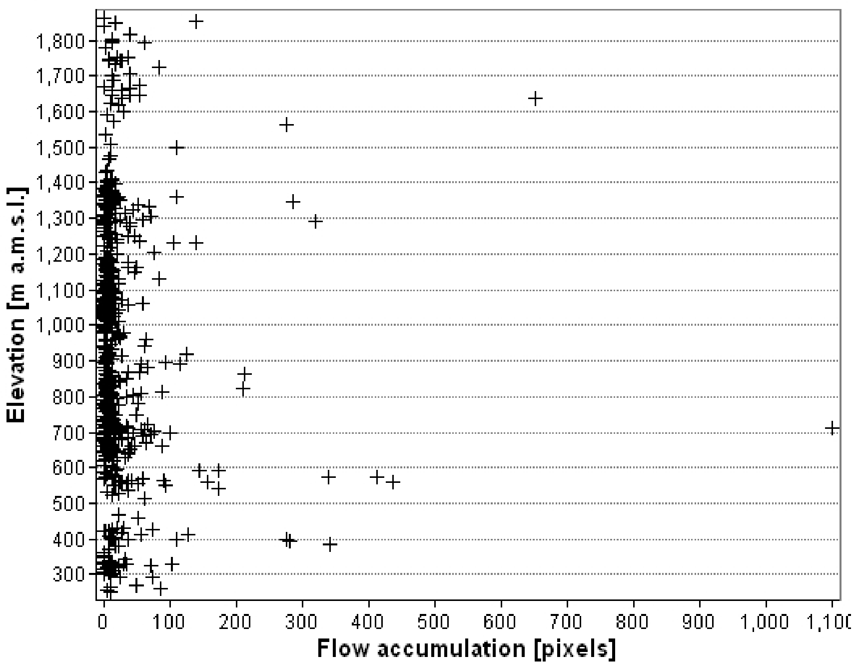
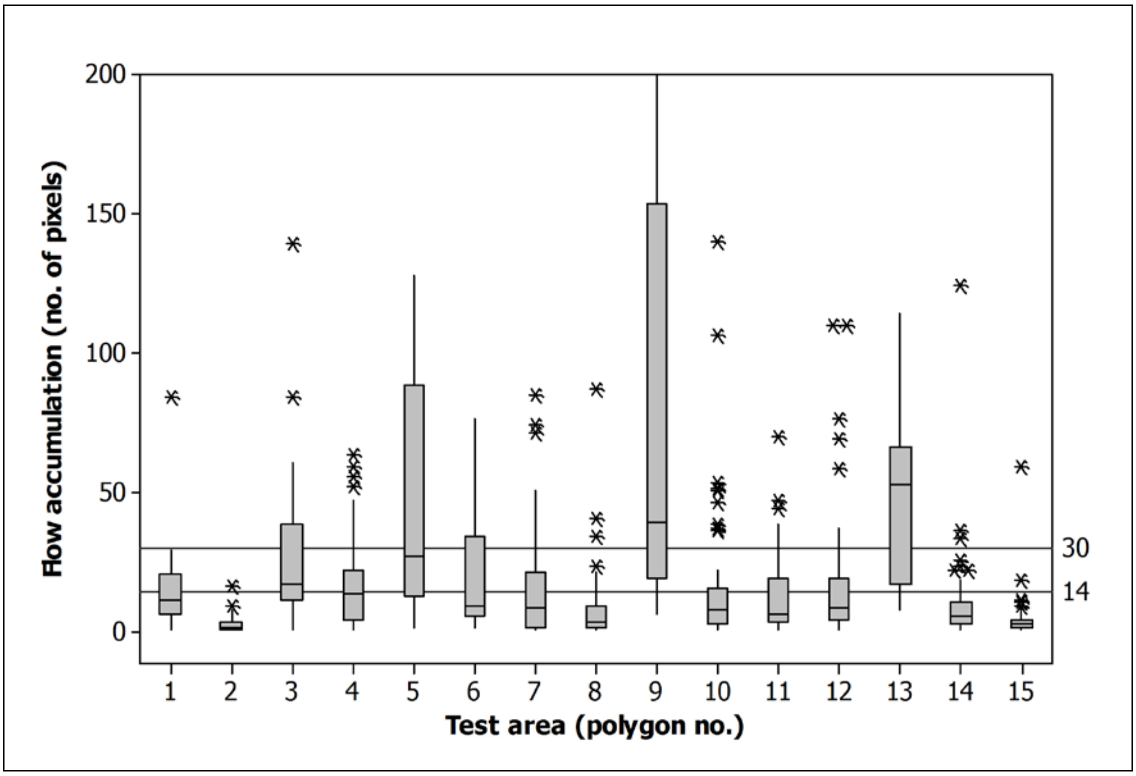


Figure 4 below shows the distribution of the catchment areas of the channel heads in each test area. Catchment area is given as number of flow accumulation pixels (pixel size 20m x 20m). Reference lines are shown for the average mean (30) and average median (14) catchment area, calculated from test area averages resp. medians. The median is 14 pixels (0.56ha or 5600m^2) while the mean is 30 pixels (1.2ha).

Figure 4: Flow accumulation values of stream starting points per test area (flow accumulation grid: 20m x 20m)



The median of the channel heads' catchment area, i.e. 5600m^2 respectively 0.56ha, was finally used as the stream definition threshold for the stream definition process. Even though the threshold was derived from topographic maps, a comparison with actually measured catchment areas of channel heads puts it into a real life perspective. Actual measurements of channel head catchment areas are rather rare in the literature. Tarolli and Dalla Fontana (2009) had assessed 30 channel heads in an alpine region in northeast Italy and found catchment areas between 0.01ha and 9.7ha, with a mean catchment area of 0.70ha and a median of 0.15ha. Henkle et al. (2011) had mapped 78 channel heads in the semiarid Colorado Front Range and had determined their mean catchment area to be 10.8ha. Montgomery and Dietrich found catchment areas between 0.1ha and 4ha, with most cases smaller than 1.5ha, from studying 68 channel heads in Marin County, California (Montgomery and Dietrich, 1989) and between 0.6ha and 9ha for 33 channel heads in the southern Sierra Nevada, California (Montgomery and Dietrich, 1988). From the above it becomes clear that the results of this study, as derived from topographic maps, are in the range of field data reported in the literature and I concluded that the stream definition threshold is suitable for further use in the stream definition process.

The TauDEM software package (Tarboton et al., 2009, Wallis et al., 2009; http://www.engineering.usu.edu/dtarb/taudem) was subsequently used for the stream definition process. Pits were filled and flow direction, slope and contributing area grids were created using the “D8 flow direction” and “D8 contributing area” tools. For the stream definition, the Peuker Douglas algorithm with manual stream definition threshold (“Accumulation threshold”) was applied to create the stream raster grid; as stream definition threshold, 5600m^2 (0.56ha) was used as described above. As final step using the TauDEM software suite, the “Stream Reach and Watershed” tool was used to yield the stream order grid and the stream reach shapefile; the latter represents a dense Cyprus-wide network of 58859 stream reaches (incl. 29989 first order streams) with morphological attributes, e.g. catchment area and stream order, at the reach level.

The next step was to define the river outlets (river mouths) of all catchments with area equal or larger than 10km^2. This threshold is prescribed by WFD Annex II for the system A of differentiating water bodies into types, and WFD CIS Guidance Document 2 recommends using this threshold for system B too, in order to “achieve the same level of differentiation” as system A (European Commission, 2003a, p.12). It was also shown in the literature review (chapter 2.2.1) that this threshold was applied by a number of other E.U. countries. In total, 74 outlets were created in this initial phase.

The DProf study did not investigate for WFD water bodies in those areas of the Republic of Cyprus, in which the Government of the Republic of Cyprus does not exercise effective control, because there is no data on the streams in this area. However, all rivers that have at least a part of their catchment in the area under Government control were included in the present study, irrespective of the fact that e.g. their river mouth is in the areas of the Republic of Cyprus, in which the Government of the Republic of Cyprus does not exercise effective control.

Subsequently, the “Batch Subwatershed Delineation” tool of the Arc Hydro for ArcGIS 10.1 software suite (version 10.1, March 27 2013) was used to combine the outcome of the stream definition process and the river outlets for the creation of catchment polygons, yielding one polygon for each river outlet.

Utilizing further the above results and especially the Cyprus-wide network of stream reaches with morphological attributes at the reach level, quantitative criteria were applied for the consistent identification (European Commission, 2003a) of those river sections that would become WFD water bodies. The following criteria were finally adopted and implemented:

- A minimum catchment area of 10km^2 was applied, both on the level of main streams and on tributary level (cf. reference to the 10km^2 threshold above).

- 1st order streams were not taken into account and removed from the stream network.
- The headwater streams that would be retained were selected based on catchment size.
- Delineated streams were checked for the existence of a corresponding stream bed on aerial photographs and satellite imagery, and delineated streams without existing streambed were removed.

For the implementation of the E.U. Floods Directive 2007/60/EC, nineteen areas of potential significant flood risk had been identified in Cyprus (WDD, 2011). With respect to their identification as WFD water bodies it was agreed, in the course of the stakeholder consultation (cf. chapter 4.2.5), that no special identification criteria would be applied for the streams in the flood risk areas. Following from that, only streams that fulfilled the stream selection criteria of the DProf project mentioned above were identified and streams that did not fulfill these criteria were not identified as WFD water system, irrespectively if they were located in flood risk areas. The application of this approach led to the identification of 17 of the 19 flood risk areas as WFD water systems, while two were not considered: Argaki Vasilikou (Paphos) due to small catchment area (<10km^2) and the Ormideia area; the latter has a catchment area of 25.9km^2 but the area is flat and I did not identify a natural river bed in the area.

3.1.3 Elaboration of the new river typology

Methodological considerations

For the sub-component (2) “Elaboration of the new river typology” the research question is “Is it possible to typify Cyprus rivers using stream flow characteristics, in a way that is compliant with the WFD and suitable for its implementation?”. In more detail, the question was whether characteristics can be identified from available stream flow data from monitoring stations that allow the grouping of stations by common characteristics. The characteristics of these groups in turn must be such that they facilitate the elaboration of improved monitoring programmes and management measures, i.e. they must be related to the quality elements required for monitoring and in particular to the biological quality elements.

In terms of constraints, the new river typology had to be compliant with the WFD text itself as well as with the related WFD CIS Guidance Documents. Another constraint was the available stream flow data themselves: these data pose temporal and spatial limitations with respect to the coverage of the Cyprus river network with monitoring data, i.e., inevitably there were streams for which no stream flow data were available.

The methodology of sub-component (2) “Elaboration of the new river typology” of the DProf project took an objective approach and drew on quantitative methods to analyze observational data of a natural phenomenon. Because the observational data had already been collected by Cyprus' Authorities over the last decades since the 1960s, the analysis is being designed "back to front" (Hakim, 1987, in Robson, 2002, p.362), meaning that instead of designing the study and then collecting the data, it started by finding out what data are available and then identified a possible research model. In fact, this is not an unusual situation in hydrology because stream flow data are routinely collected all over the world in a standardized way and, consequently, it is the case that many methods of hydrological analysis and software have actually been developed "around" this very type of data. I consider, therefore, that hydrologists accept this potential limit to their choices in research methods due to the fact that it is, for a researcher, usually impossible to embark on the very costly and time consuming exercise of collecting long term stream flow data.

The stream flow data were drawn from the relevant WDD database, to which I have direct access as I am coordinating the stream flow monitoring in Cyprus. Stream flow is stored as mean daily flow values, i.e. one value per day, and it is a continuous variable. It can take on every positive value, and zero which represents no flow. These data have been collected by the WDD since 1965 from its network of stream gauging stations that covers the largest part of the island; thus, the observational part of my project, in the sense of Rhoads and Wilson (2010, p.29) who have found that "currently in the natural sciences, observation is viewed as data gathered using elaborate theory - dependent processes that often involve instrumentation", has already been carried out. The data collection process mentioned is in line with the view of the post-positivist paradigm which accepts the theory-ladenness of observation, because the technology employed for data collection "draws on background knowledge about how specific technologies can generate data" (Rhoads and Wilson, 2010, p.29).

Implementation – project activity

According to Annex II of the WFD, surface water bodies shall be differentiated according to type. The types shall be defined using either system A by means of fixed factors or system B by means of obligatory and optional factors; the latter allows "Member States to use as many or as few of the optional factors as needed" (Logan and Furse, 2002, p.428). The main purpose of the types is the reliable definition of type specific biological reference conditions.

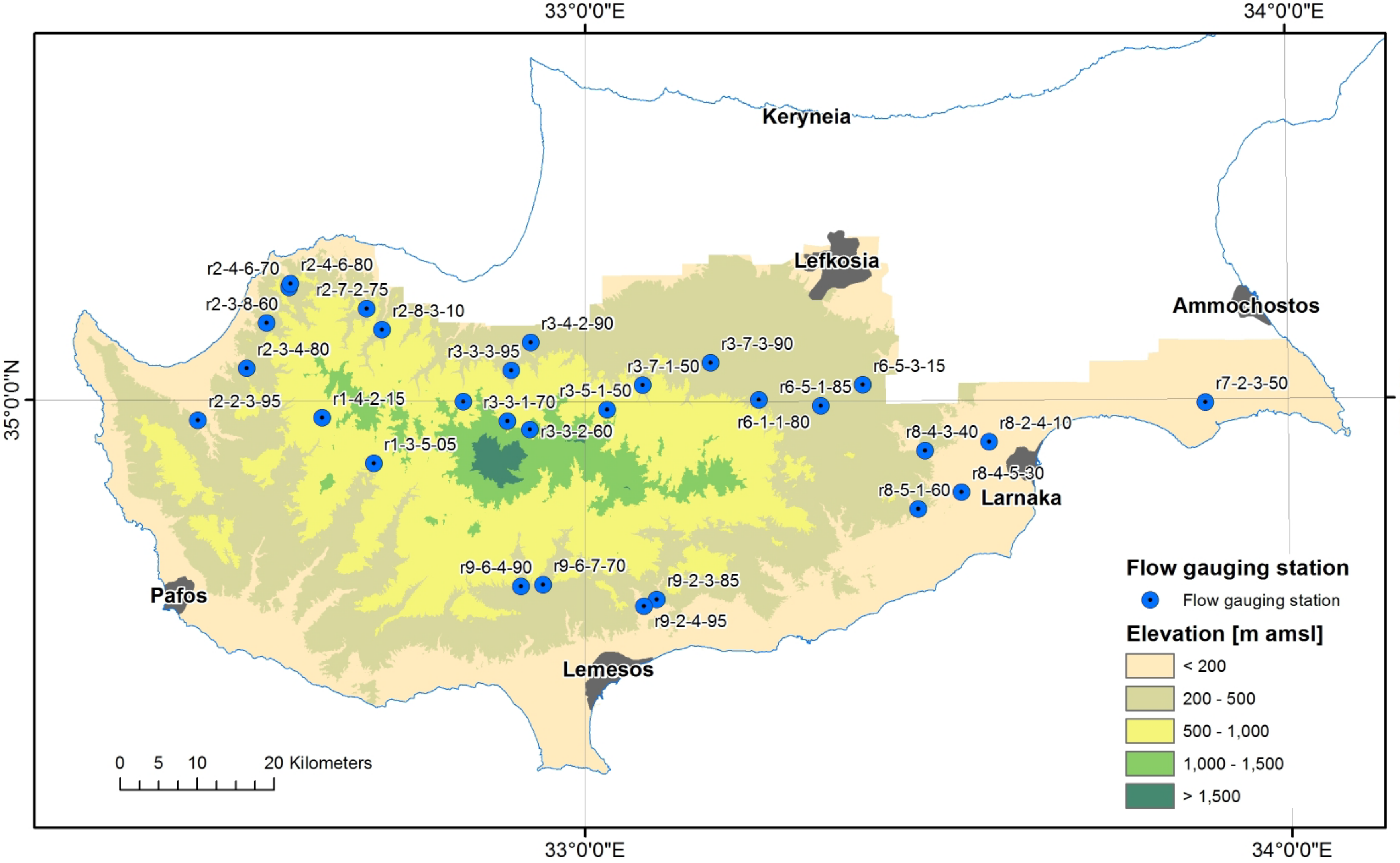
For the first RBMP and management cycle, three river types had been defined by WL | Delft Hydraulics et al. (2004) according to system "B" using the factors "annual rain volume" (over the catchment) and "flow continuity".

As already mentioned in Chapter 2 above, the flow regime is of immense importance for Mediterranean lotic ecosystems, a fact that has been recognized in many scientific works related to the topic (e.g., Argyroudi et al., 2009, Sánchez-Montoya et al., 2012, Nikolaidis et al., 2013). In addition, the factor “river discharge (flow) category” is included as optional factor in system B and is, therefore, acceptable for WFD typologies. Based on the above, it was decided to attempt to base the new Cyprus river typology on the different flow regimes present on the island and to use local stream flow data for its determination. To this end, stream flow time series from 29 flow gauging stations without major impact on hydrology for the period 1985/86-2004/05 (20 years) were selected. The 29 stations are presented in Table 2 and Figure 5.

Table 2: Twenty nine (29) flow gauging stations selected for river typology elaboration

Flow gauging station code	River name	Location name	Elevation [m amsl]	Catchment area [km^2]
r1-3-5-05	Xeros	Lazarides	430	67
r1-4-2-15	Agia	Agia Forest Station	600	22
r2-2-3-95	Chrysochou	Skoulli	90	64
r2-3-4-80	Makounta	u/s Argaka Dam	140	45
r2-3-8-60	Gialia	Pano Gialia	190	15
r2-4-6-70	Leivadi	u/s Pomos Dam	160	28
r2-4-6-80	Mavros Kremmos	u/s Pomos Dam	160	5.1
r2-7-2-75	Pyrgos	Fleva	200	38
r2-8-3-10	Limnitis	Saw Mill	255	48
r3-2-1-85	Marathasa	u/s Kalopanagiotis Dam	579	23
r3-3-1-70	Agios Nikolaos	Kakopetria	781	16
r3-3-2-60	Platania	Kakopetria	853	10
r3-3-3-95	Kargotis	Evrychou	396	63
r3-4-2-90	Atsas	Evrychou	291	33
r3-5-1-50	Lagoudera	Lagoudera Br.	620	13.5
r3-7-1-50	Peristerona	Panagia Bridge	414	77
r3-7-3-90	Akaki	Malounta	350	90
r6-1-1-80	Agios Onoufrios	Kampia	405	14.5
r6-5-1-85	Gialias	Kotsiati	300	73
r6-5-3-15	Gialias	Nisou	230	91
r7-2-3-50	Liopetri	Liopetri	30	11.5
r8-2-4-10	Aradippou	Aradippou	56	53
r8-4-3-40	Treminthos	Agia Anna	135	94
r8-4-5-30	Treminthos	Klavdia	63	135
r8-5-1-60	Pouzis	Alethriko	142	19.5
r9-2-3-85	Germasogeia	Foinikaria	100	110
r9-2-4-95	Gialiades (Akrounta)	u/s Germasogeia Dam	90	31
r9-6-4-90	Kouris	u/s Kouris Dam	290	96
r9-6-7-70	Limnatis (Zygos)	u/s Kouris Dam	277	115

Figure 5: Twenty nine (29) flow gauging stations selected for river typology elaboration



In their study on flow regimes and lotic water typology of Austrian rivers, Mader et al. (1996) had used only time series with a length of 20 years or longer. However, the typology they developed was based on statistical parameters only without reference to their ecological meaning. For Australia, Kennard et al. (2008) reported that 15 years of discharge record was suitable for hydrologic classification analyses to detect important spatial variation in hydrologic regimes, provided that the discharge records were contained within a discrete temporal window, and they had elaborated the classification of Australia's flow regimes from time series of 15–30 years constrained within a 36-year period. Similarly, McManamay et al. (2012) had also selected stream gauges with at least 15 years of data for their study to classify unregulated streams distributed over an eight-state region in the U.S., while Peñas et al. (2014) had selected flow records with average length of 17 years for their study of the influence of methodological procedures on hydrological classification performance. From the above I concluded that the selected record length of 20 years is sufficient for the analyses of the present study.

The stations and time series were selected as the best compromise between the number of available stations and the available length of the time series "without major impact on hydrology". For the assessment of the impact on the hydrology of a station, the capacity of upstream dams and ponds was evaluated in relation to the mean annual flow of the stations. Stations where the upstream storage capacity was greater than 10% of the mean annual flow were rejected. In cases where flow data was available, the time series was checked for differences between the pre- and post-impact periods. This approach is similar to the one described by Kennard et al. (2008) for Australia since in Cyprus, too, flow data from a period prior to the imposition of anthropogenic impacts do not exist for much of the area and, to overcome this shortcoming, considerable effort has been taken to ensure that all utilized stream gauges are minimally disturbed by human activities. Similarly, Poff and Ward (1989) report of having made an attempt to include only streams with minimal perturbation by e.g. excluding streams that had more than minimal upstream diversion for irrigation and water supply. Concluding from the above, however, the flow regimes considered in the present study are near-natural contemporary flow regimes, and not the natural flow regime.

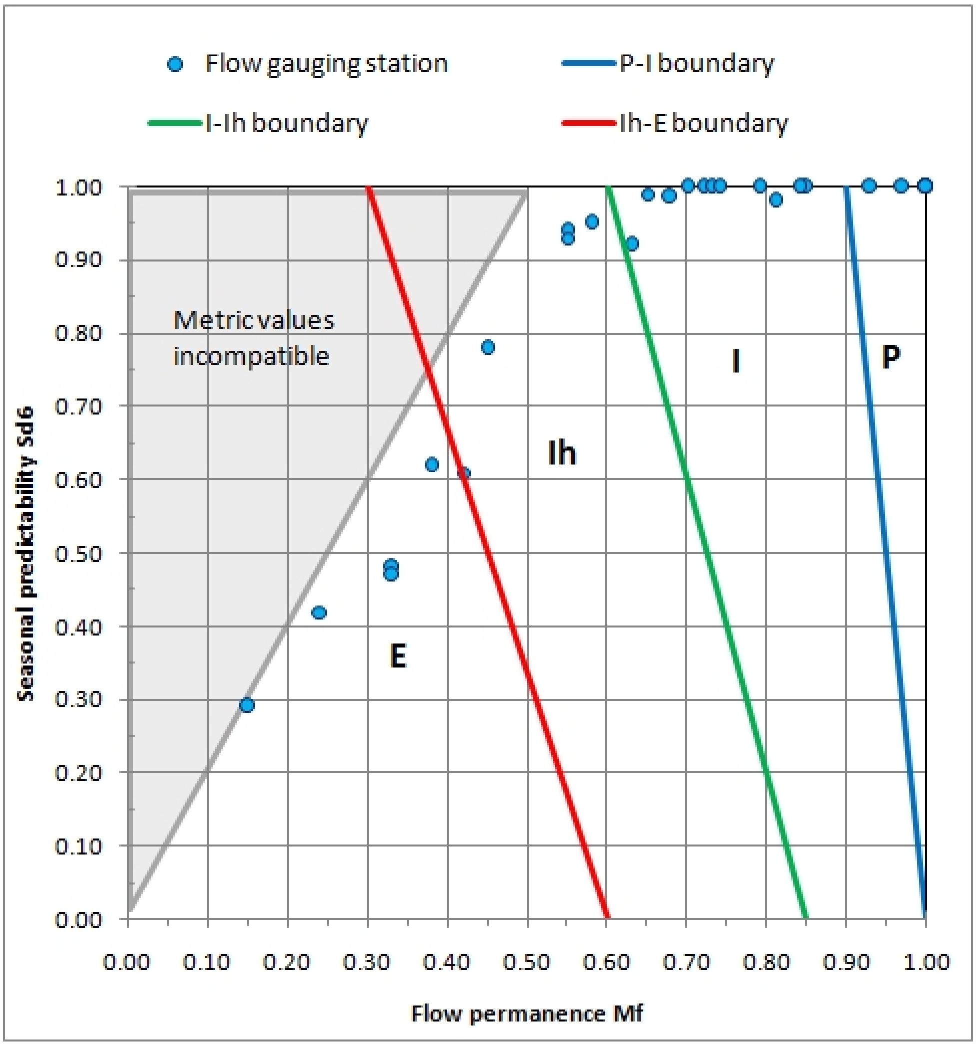
A number of methods and indices describing hydrological characteristics were applied to the data in order to group rivers according to similar hydrological characteristics that relate to biota response and facilitate efficient future monitoring and management. The Temporary Stream Regime Tool (TSR-Tool) described by Gallart et al. (2012) was finally adopted as basis for the new stream typology.

The TSR-Tool requires the calculation of two metrics from the stream flow data:

- The long term mean annual relative number of months with flow, Mf (taking values between 0 and 1)
- The six-month seasonal predictability of dry periods, Sd6 (taking values between 0 and 1)

The two regime metrics are plotted as x,y data on the Temporary Stream Regime Plot (TSR plot) where, according to the boundaries between the regime types given by Gallart et al. (2012), their plotting position determines the classification into one of four flow regimes: P (Permanent or perennial), I-P (intermittent-pools), I-D (intermittent-dry) and E (ephemeral-episodic); type I-P was finally named intermittent (I), and type I-D was named harsh-intermittent (Ih) for the proposed new Cyprus typology. The TSR plot with the abovementioned 29 Cyprus flow gauging stations is shown in Figure 6 below:

Figure 6: Temporary Stream Regime Plot (TSR plot) after Gallart et al. (2012) of the 29 selected Cyprus flow gauging stations. Time series 1986-2005.



Reasoning for the adoption of the TSR-tool

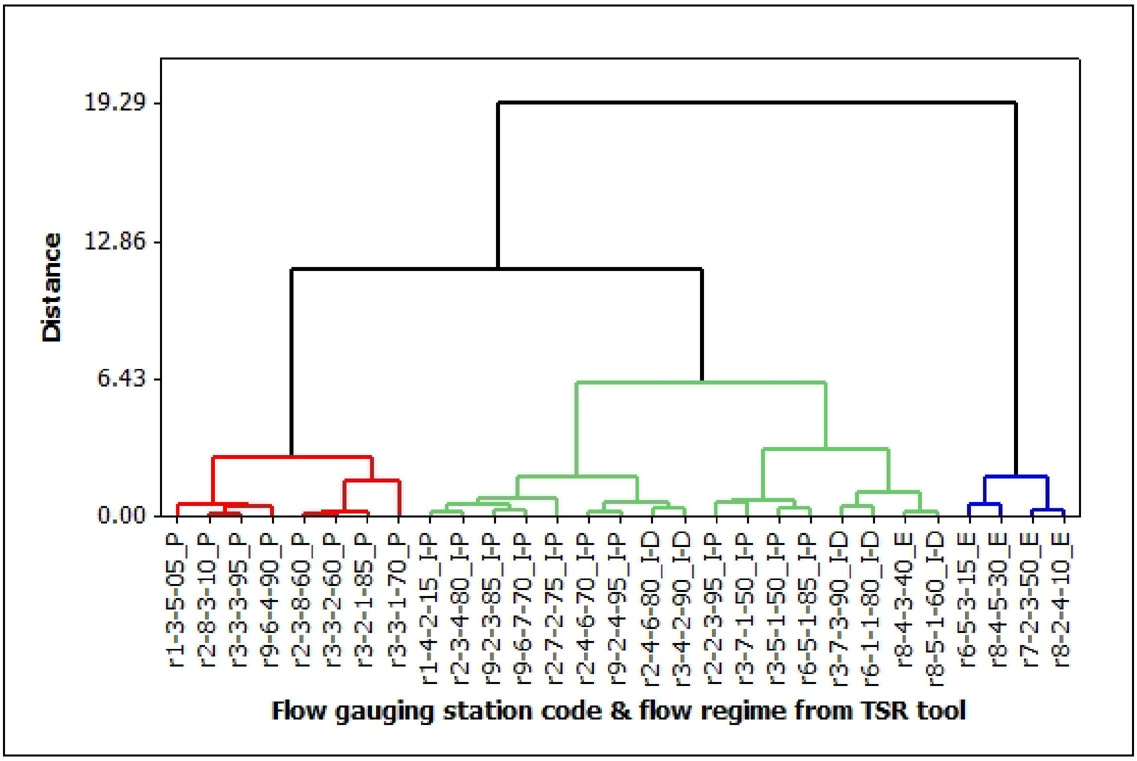
Several reasons led to the adoption of the TSR-Tool:

While many stream flow regime classification studies addressing the whole gradient of flow permanence, i.e. from perennial to ephemeral/episodic, were based on more sophisticated statistical approaches e.g. Principal Component Analysis (PCA) and cluster analysis techniques (cf. chapter 2.2.2), it was found that the few classifications that refer to mainly or exclusively temporary flow regimes (Gallart et al., 2012, Snelder et al., 2013) have used simpler approaches (cf. chapter 2.2.2). In that respect it is interesting to observe that Ton H. Snelder, who was involved in a number of pertinent publications especially on works in France and Spain, had applied flow regime classification addressing the entire flow domain using multiple parameters and sophisticated statistical approaches in earlier studies (Snelder et al., 2009) and later on, when addressing exclusively temporary flow regimes, he and his co-authors resorted to a much simpler approach (Snelder et al., 2013).

Still, I considered that the applicability of the TSR-tool had to be checked, in the sense of a triangulation of the results. Especially the fact that one of the authors of the TSR-tool (Prat, pers. comm. 06/Sept/2013) had informed me that the “boundaries” between the flow regimes had been set tentatively in Gallart et al. (2012) indicated that in particular a check of these boundaries was needed. For carrying out the check, I used clustering analysis with parameters that had been used by similar studies in the Mediterranean area (De Girolamo et al., 2008, Oueslati et al., 2010) and that had been shown to represent statistically independent aspects of streamflow in streams of the western United States (Chinnayakanahalli et al., 2011) and compared the results with the outcome of the TSR tool.

The same dataset as for the creation of Figure 6 was used, input variables were standardized and Ward’s linkage method and Euclidean Distances were applied. Several combinations of the hydrological parameters “number of zero flow days”, “flow predictability”, “base flow contribution (fixed interval method)” and the flashiness index (Baker et al., 2004) were tested, and all yielded very similar results; the flashiness index was used in ln-transformed format to make it fit a normal distribution. No further data treatment or preparation was undertaken because the clustering yielded very clear results from the very first trials. Exemplarily, one resulting dendrogram is shown in Figure 7, and each flow gauging station code on the x-axis also shows, as suffix, its flow regime as it had resulted from the application of the TSR tool (Figure 6). Figure 7 clearly shows participations into perennial (P), intermittent (I-P & I-D) and ephemeral flow regime (E), while the intermittent cluster shows discrimination of the stations with I-P regime towards the perennial (left) side and of the I-D regime towards the ephemeral rivers on the right (regime E). The intermittent cluster in the middle of the dendrogram shows some overlap between I-P and I-D stations, indicating their similarity. An interesting case is the station with code r8-4-3-40_E, which is mixed in between I-D stations on Figure 7, while on Figure 6 (without labels) it is right on the boundary between flow regimes E and I-D, thus supporting that the TSR tool and the cluster analysis give, with the Cyprus data set used here, very similar results.

Figure 7: Dendrogram from cluster analysis of the 29 selected Cyprus flow gauging stations. Input parameters: number of zero flow days, base flow contribution (fixed interval method), ln(flashiness index)



Concluding, the cluster analysis confirms the flow regime “classification” and also the boundaries derived with the TSR tool and supported me to adopt it for the DProf project.

Apart from the fact that the TSR tool is considered fully suitable for the purpose as far as the technical side is concerned, another reason supporting the decision emerged from the outcome of the stakeholder consultation. The general lack of knowledge on the topic even by colleagues led me to conclude that a simpler method would also be easier to explain to them and this would contribute to improved implementation and quicker uptake. This reasoning is in line with Snelder and J. Booker (2013) who recommended to consider ease of explanation as one criterion for deciding on a flow regime classification method.

The Cyprus stream flow data allowed covering the whole range of flow regimes from perennial to intermittent and to ephemeral-episodic, as described in e.g. Uys and O’Keeffe (1997) and in the paper by Gallart et al. (2012) that introduced the TSR tool. Despite its apparent obviousness, this fact is an important precondition for basing a river typology on stream flow data from existing stations. In the opposite case, if the available data would not cover the whole gradient of flow regimes, this would mean that there is a chance for types that are not covered by monitoring stations, in case these types exist in reality, to be missing in the resulting typology. The note of Kennard et al. (2008, p.36) with respect to their results is pertinent; they write to have distinguished 12 flow regime types on the Australian continent “at least for the stream gauges included in our analyses”, thus expressing their uncertainty whether or not their dataset covers all flow regimes. A similar situation is expressed by a quote of Oueslati et al. (2015, p.19) who identified six distinctive flow regime types in the Mediterranean region, “at least for the 60 rivers included in this analysis”.

Lack of flow gauge records from temporary rivers has been lamented by a number of writers (e.g., Tzoraki and Nikolaidis, 2007, Snelder et al., 2013, Datry et al., 2014, Peñas et al., 2014). Especially ephemeral rivers may not have been included in stream flow monitoring programmes due to the “reluctance to invest in gauging structures” in areas where “rainfall-runoff is both spasmodic and sporadic” that had been identified by Reid et al. (1998, p.543) or simply because they are “less valued by society than permanent streams or longer-flowing temporary streams” (Boulton, 2014, p.734). In fact, the case of Cyprus appears to be an exception as it has flow gauging records covering the whole gradient of flow permanence.

The authors of the TSR-Tool (Gallart et al., 2012, Prat et al., 2014) clearly relate the four stream types to the relevance of biological communities for monitoring purposes; therefore, the types defined by the TSR-Tool will facilitate adjusting the biological monitoring according to type. For example, Gallart et al. (2012, p.3173) state that for biological quality assessment of ephemeral (E-type) streams “other methods beyond the customary study of aquatic fauna” are needed and that “these methods are not yet available to managers” (Gallart et al., 2012, p.3179). For intermittent streams, they specify that samples must be taken, at the earliest, after flow has resumed in the stream and has been present in it for at least a month, thus giving clear justification for not applying BQEs if this condition does not occur in a certain year in an intermittent stream; such situations are common in dry years in harsh intermittent (Ih type) rivers. The fact that BQEs are not every year applicable in type Ih is also due to the wide inter-annual variation of their biological communities (De Girolamo et al., 2014).

The TSR gradient from perennial to ephemeral/episodic streams represents as well a gradient of predictability that is contributed by the Sd6 metric. Because there is a relation between predictability of hydrologic events and difficulty in planning activities in temporary rivers (Davies et al., 1994), the TSR results provide an indication of the difficulty in planning e.g. monitoring in the different stream types, which is expected to contribute to improved monitoring organization.

Snelder and J. Booker (2013) recommend that when selecting methods for defining flow regime classifications, aspects such as flow data requirements should be considered too. The TSR method is very favourable in that respect because TSR types can be elaborated based on monthly spot measurements of stream flow, as it has been shown in this study by successfully using such data to determine TSR characteristics.

With respect to chemical monitoring, Prat et al. (2014) suggest to analyze fluvial sediments in the case of I-D (intermittent-dry) and E (ephemeral-episodic) rivers. Thus the differentiation of the rivers according to the types of the TSR-tool allows for future improvement of the chemical monitoring, in addition to the benefits for biological monitoring mentioned above.

Compliance of new typology with Cyprus' results of the Intercalibration Exercise

A major concern with respect to WFD river types is their compliance with the existing results of the Intercalibration Exercise (European Commission, 2013b). The typology that was elaborated according to Gallart et al. (2012) by using the TSR-tool is fully compliant with the Cyprus IC results for the reasons which follow.

As far as perennial rivers are concerned, only one perennial river type (R2) had been identified in Cyprus in the past. Cyprus had participated with this single national perennial type in the IC exercise and it corresponded to IC type R-M4. The existence of only one perennial river type was confirmed by the present study and with the methodology described above this type was named "P". It is clear that the reference conditions of this single existent type do not change because the rivers it encompasses do not change. Therefore, there is a direct correspondence between the old national type R2, the intercalibrated IC type R-M4 and the new national type P.

In addition, it is worth noting that in the IC exercise for benthic invertebrates in Mediterranean rivers (Feio, 2011, p.32) "a common boundary was defined within the MedGIG for types RM1, RM2 and RM4" and that "the respective Member State boundaries were harmonized together". Equivalent common boundaries were also defined and used for harmonization of Member State boundaries for the BQEs "aquatic macrophytes" (Aguiar, 2011) and "phytobenthos (diatoms)" (Almeida, 2011). As a consequence, it becomes clear that all national types are to be harmonized against the same single set of boundaries (High/Good and Good/Moderate) and a change in a national type does not impact on compliance with IC results, as long as the new national types refer to river types, or rivers, that had been intercalibrated before.

With respect to temporary rivers there was only one corresponding river type in the IC exercise (R-M5), i.e. the quality targets of all national types of Mediterranean temporary rivers were harmonized against this single type. Cyprus had never distinguished its national temporary river types R1, R3, neither for the determination of national boundaries, which were derived for all temporary rivers together without distinction between R1 and R3, nor for the participation in the IC exercise, where all data from temporary rivers were delivered to the Med GIG as type R-M5 – the data had not been distinguished into the national types R1 and R3 because they were not suitable for this purpose.

In Cyprus, all temporary rivers that can be monitored for WFD biota were always treated together as R-M5 type, and this included all river reaches of type I-P and river reaches of type I-D in years when abundant streamflow allowed their monitoring. Rivers of type E were not included as their flow regime does not allow the monitoring of WFD biota.

Following from the above, the new proposed type I-P corresponds directly to the IC type R-M5. In years when a river of type I-D proves to be "monitorable", it will be assessed with the same method and reference conditions as the I-P type, but the results will be subject to scrutiny regarding the uncertainty inherent in the results for I-D rivers. Rivers of the new proposed type E will not be assessed by BQEs at all and they do not correspond to IC type R-M5.

The fact that both I-P and I-D type rivers are proposed to be assessed with the same assessment method, i.e. against the same reference conditions, may raise the question why they are not treated as one single type. The necessity to treat them separately arises from their different characteristics as described in Gallart et al. (2012) and Prat et al. (2014) that lead to the conclusion that the two intermittent types are needed mainly for operational and administrative reasons, due to the fact that monitoring of the I-D type needs continuous flexible adjustments of the sampling schedule to the prevailing hydrological conditions, while the I-P type streams can be monitored with a rather fixed schedule because their flow regime is much more stable.

3.1.4 Mapping river types onto the river network

Methodological considerations

The sub-component (3) "Mapping river types onto the river network" poses important research questions such as "How to determine the spatial limits of types in each river?" or "How to classify ungauged rivers?".

The work for this sub-component pulled together all available information on the hydrological regimes of Cyprus rivers. To this end it used the results of the river typology determination of sub-component (2). It was supplemented with evidence inferred from secondary data and with information gathered from selected resource persons through personal communications; these communications took the form of short unstructured but precisely targeted interviews.

In cases where both the above approaches did not yield results, I applied my personal expert judgement. All information was drawn together and analyzed in a Geographic Information System.

Implementation – project activity

The next step towards the new river water body network was the combination of the newly delineated stream network with the newly established river types. This process would yield a network of stream reaches where each reach would correspond to one of the river types determined in chapter 3.1.3 above. The working units for this procedure were the historic Cyprus subcatchments that had been elaborated by Toufexis et al. (1970). River types would be assigned to river reaches corresponding to these subcatchments; still, the existing historic Cyprus subcatchments did not include subcatchments for a number of main tributaries that were included in the newly delineated stream network. Therefore, the subcatchment GIS layer was adjusted by including catchments for these tributaries, yielding a final set of 433 subcatchments covering the whole island (Figure 8). 143 of the 433 are located in those areas of the Republic of Cyprus in which the Government of the Republic of Cyprus does not exercise effective control.

By intersecting these 433 subcatchments with the newly delineated stream network, a network of 232 stream reaches resulted. The number of stream reaches is significantly smaller than the number of subcatchments because many subcatchments correspond to very small rivers that do not meet the criterion of minimum catchment size that had been applied for consideration as WFD stream (cf. chapter 3.1.2 above). Such cases occur along the entire northern coast of Cyprus and in the Karpasia peninsula in the northeast, but also in the Akamas peninsula in the west of the island, as can be seen on Figure 8. These rivers are, as far as this study has concluded and with few exceptions, all of ephemeral and episodic type.

In addition it should be noted that from the 232 reaches, 8 are in those areas of the Republic of Cyprus in which the Government of the Republic of Cyprus does not exercise effective control and they were not assigned a stream type due to lack of data.

The assignment of stream types to river reaches was carried out following the steps below:

Step 1

Reaches where the flow had been monitored over some period of time at monitoring sites and thus their river type could be determined from flow records; such reaches could be assigned their river type directly. The monitoring sites that were used are shown in Figure 9.

Figure 8 : Historic Cyprus subcatchments and the revised WFD stream network

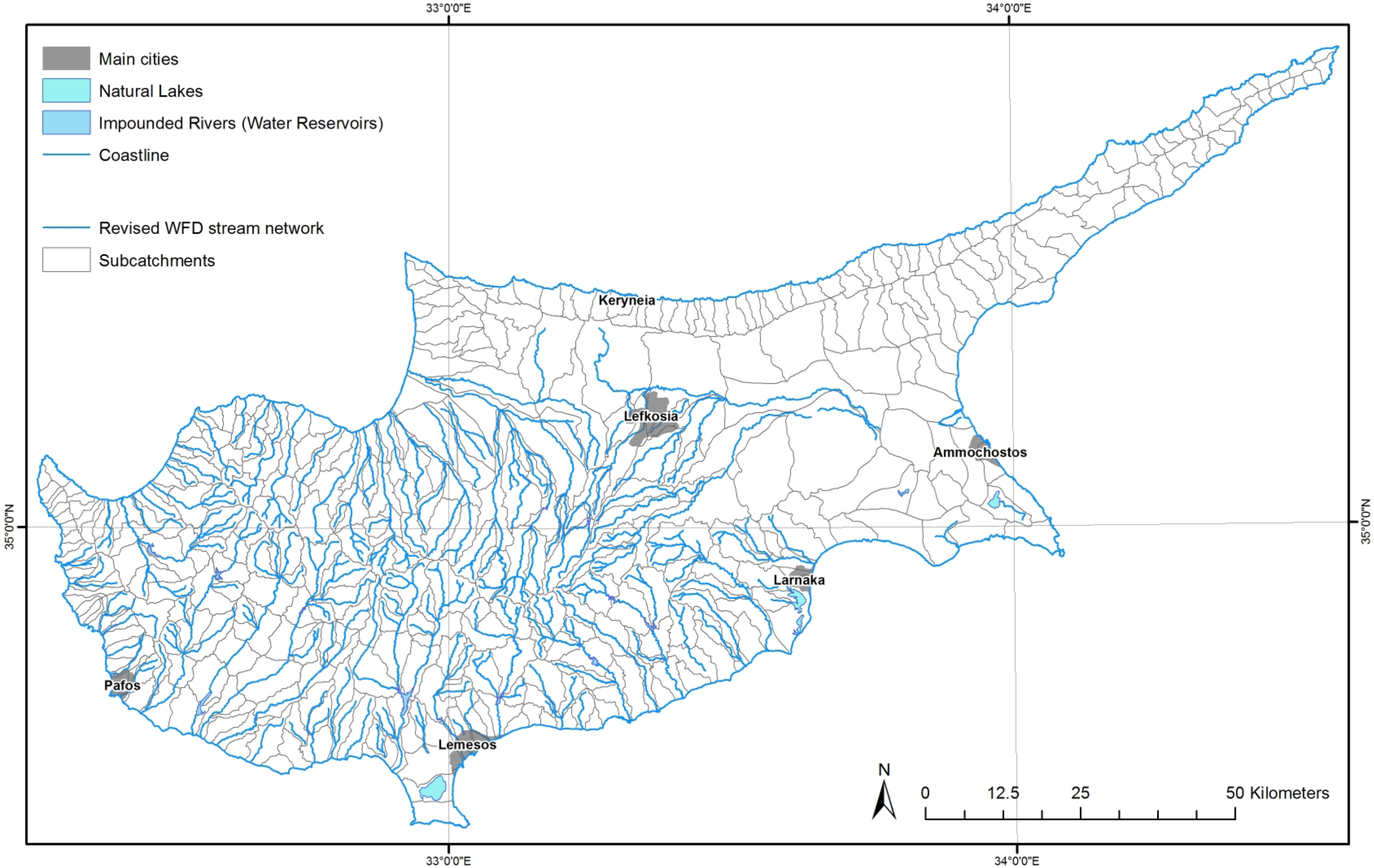
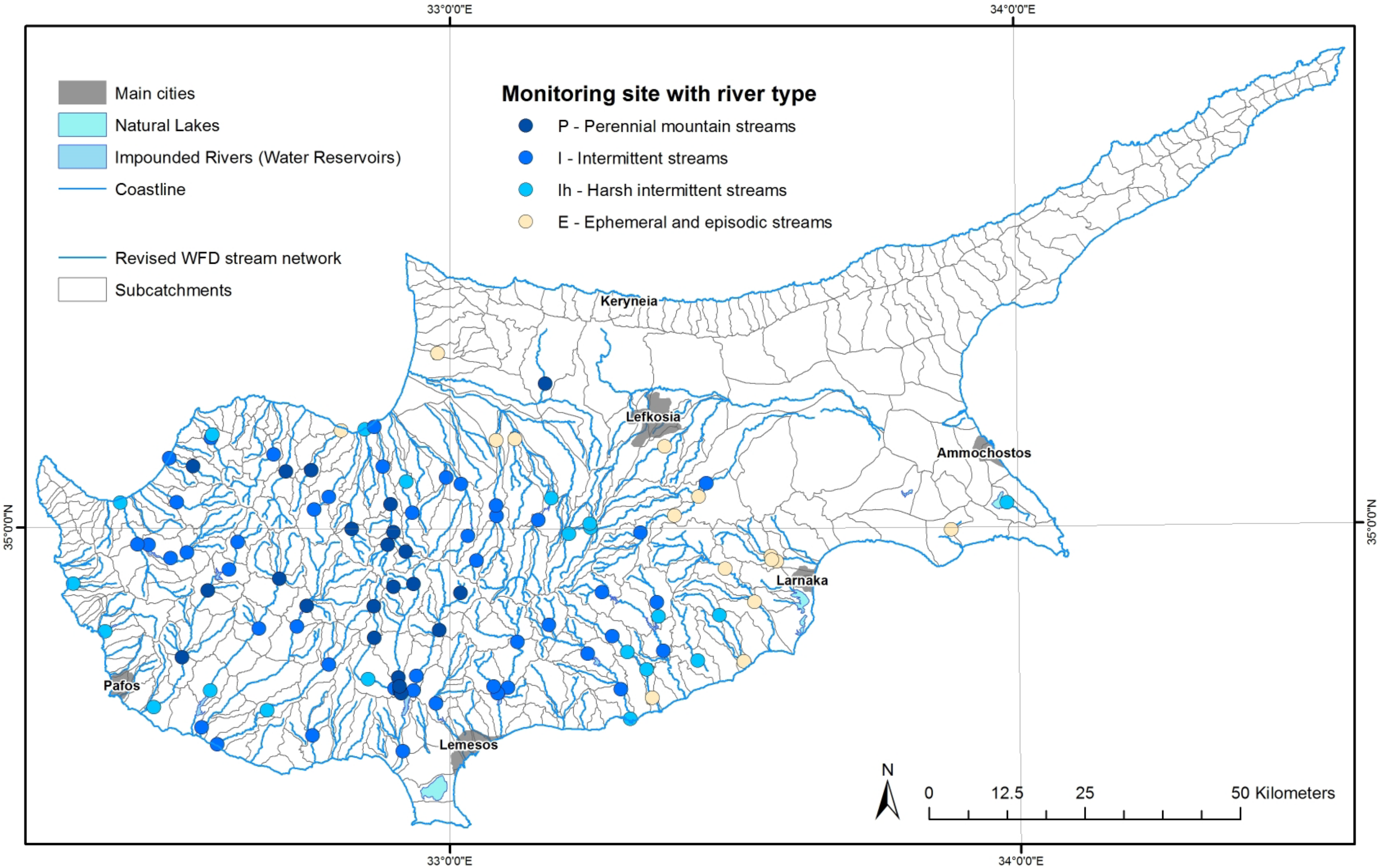


Figure 9: Historic Cyprus subcatchments, revised WFD stream network and flow monitoring sites with their river type



Step 2

In ungauged reaches, their catchment characteristics were used as proxies to determine their flow regime. To this end, relationships between river types and several catchment characteristics were investigated in gauged catchments using box plots. Criteria and thresholds for the assignment of stream types were established and these, in turn, allowed assigning river types to ungauged stream reaches based on catchment characteristics.

It is important to note at this point that on one hand the working units are the adjusted historic subcatchments that correspond to river reaches, i.e. subcatchments being ordered from the headwaters to the river mouth without overlaps. On the other hand, the catchment characteristics utilized for each subcatchment are those representing the whole catchment from the respective subcatchment's outlet up to the water divide, i.e. including also the areas of the subcatchments further upstream. This approach is necessary because methodologically, the subcatchments' catchment characteristics must be based on the same spatial extent as the gauged catchments used to define the relationships between TSR and catchment characteristics – and these gauged catchments are always being considered as entire catchments from outlet to water divide. This approach is also well-founded in the sense that the river types determined at gauging stations are strictly valid only in the vicinity of these gauging stations while obviously the entire catchment upstream of the station determines the very river type in the stations' vicinity; consequently, it is correct to assess the river type of the most downstream subcatchment using the catchment characteristics of the entire catchment.

In a first attempt, river types and catchment characteristics were investigated using the group of 29 flow gauging stations without major impact on hydrology that had been used in Table 2 in chapter 3.1.3 above.

Normality tests (Kolmogorov-Smirnov with Lilliefors criterion, Shapiro-Wilk) were carried out on catchment characteristics' datasets of the abovementioned stations. These catchment characteristics included all the typology parameters given in Annex II of the WFD for which suitable data was available. For the catchment characteristics "Mean catchment elevation", "Precipitation over catchment" and "Mean stream slope", H0 could not be rejected and the data was subsequently considered to be normally distributed; for all other tested catchment characteristics, H0 had to be rejected at alpha=0.05 and these data cannot be considered to follow a normal distribution.

Datasets were grouped according to the river types (TSR types), and box plots were created to assess for which catchment characteristics there is a distinction between the river types. These box plots are shown in Appendix 1. On the box plots, most catchment characteristics showed a gradient from the perennial (P) to the ephemeral (E) river type and visual assessment suggested differences between the types in several cases. Subsequently it was tested whether statistically significant differences exist between types.

In catchment characteristics' datasets where the H0 of a normal distribution could not be rejected, one-way ANOVA was applied to investigate for differences between the means of the catchment characteristics of the river types. There were statistically significant differences between groups (alpha=0.05), as determined by the ANOVA, for all three catchment characteristics (Table 3).

Table 3: ANOVA results for differences of catchment characteristics between groups of river types. Data base: 29 flow gauging stations without major impact on hydrology

AA	Catchment characteristic	ANOVA result
1	Mean catchment elevation	$F(3,25)=10.98$, **$p<0.01$**
2	Precipitation over catchment	$F(3,25)=19.37$, **$p<0.01$**
3	Mean stream slope	$F(3,25)=7.97$, **$p<0.01$**

These ANOVA results were followed up by Scheffé post hoc tests to investigate where these differences between the types occurred and in particular if there are catchment characteristics where a type has statistically significant differences with all other types. Such differences were considered important indicators for the selection of catchment characteristics for mapping the corresponding stream types to river reaches.

- For mean catchment elevation, the Scheffé test indicated that the elevation in type P is significantly higher than in types Ih and E, while is difference with elevation in type I is only marginally significant ($p<0.1$).
- For the precipitation over the catchment, the Scheffé test indicated that the precipitation in type P is significantly higher than in all other types ($p<0.05$).
- For the mean stream slope, the Scheffé test indicated that the mean stream slope in type E is significantly smaller than in types P and I ($p<0.05$). It is also smaller than in type Ih but this difference is only marginally significant ($p<0.1$).

The above results indicate that catchment elevation and especially precipitation are suitable parameters for mapping of stream type P to stream reaches, while the mean stream slope is suitable for mapping stream type E to stream reaches.

In catchment characteristics' datasets where the H0 of normality had to be rejected at alpha=0.05, Kruskal-Wallis tests were undertaken. With 3 degrees of freedom (4-1=3), the critical value of H, approximated from the chi-square distribution and for alpha=0.05, is 7.82.

In cases where KW-H values are greater than the critical value of H, the null hypothesis must be rejected. There were statistically significant differences between groups for all five catchment characteristics and the results are shown in Table 4.

Table 4: Results of Kruskal-Wallis (KW) tests for differences of catchment characteristics between groups of river types. Data base: 29 flow gauging stations without major impact on hydrology

AA	Catchment characteristic	Kruskal-Wallis result
1	Maximum catchment elevation	KW-H(3,29)=11.32, **p =0.0101**
2	Mean catchment slope	KW-H(3,29)=14.23, **p <0.01**
3	Circum-Troodos sedimentary rocks (coverage of catchment)	KW-H(3,29)=12.04, **p <0.01**
4	Troodos Ophiolite rocks (coverage of catchment)	KW-H(3,29)=11.20, **p =0.0107**
5	Circum-Troodos Quaternary & Sedimentary* (coverage of catchment)	KW-H(3,29)=11.58, **p <0.01**

* This includes both the Circum-Troodos Quaternary and the Circum-Troodos Sedimentary Succession

These Kruskal-Wallis results were followed up by multiple comparisons of mean ranks (Siegel and Castellan, 1988, as implemented in the software Statistica 10) to investigate where the differences between the types occurred, in analogy to the Tukey HSD and Scheffé test described further above. Only for two catchment characteristics statistically significant differences were found, but these are not statistically significant at alpha 0.05 for all comparisons, as described in the following lines:

- For the percentage coverage of the catchment with Circum-Troodos Quaternary & Sedimentary rocks, the multiple comparisons indicated that the coverage in type E is significantly greater than in type P ($p<0.05$). The coverage in type E was also found to be greater than in types I and Ih, but this difference is only marginally significant for type I ($p<0.1$) and for type Ih, $p=0.11$.
- For the percentage coverage of Troodos Ophiolite rocks of the catchment, the multiple comparisons indicated that the coverage in type E is significantly smaller than in type P ($p<0.05$). The coverage in type E was also found to be smaller than in types I and Ih, but this difference is only marginally significant ($p<0.1$).

The above analysis shows that with the non-parametric tests it was not possible to identify single types where a catchment characteristic would be significantly different from all other three types, at alpha 0.05. With the parametric tests, on the other hand, such differences were identified for three catchment characteristics. Apart from the catchment characteristic's datasets being different between each other, this outcome may also be due to the fact that non-parametric procedures are generally less powerful, i.e. less able to detect existing differences, than the corresponding parametric methods. Still, even the marginally significant differences were considered as indications of existing differences, compared to cases where not even marginally significant differences were identified, and thus they also contributed to the subsequent analyses.

Concluding from the above analyses, it was possible to identify criteria and thresholds for the assignment of perennial (P) and ephemeral/episodic (E) stream types, based on statistically significant differences of certain catchment characteristics between either the P type vs. all other types or the E type and all other types. For the catchment characteristics where significant differences had been detected, criteria and thresholds were subsequently deducted from interpretation of the corresponding box plots in Appendix 1, thus yielding a first set of stream type assignment criteria.

Still, criteria and thresholds for the assignment of the intermittent stream types were lacking. It is no surprise that the distinction between the intermittent types is less clear than between the perennial and ephemeral types, because intermittent flow regimes exhibit vast temporal variation of stream flow and these reaches are typically characterized by large fuzzy zones in the sense of Uys and O'Keeffe (1997).

Step 3

For the establishment of additional criteria and thresholds addressing the above lack, the river types and catchment characteristics of an extended group of 77 flow gauging stations were used. The 77 flow gauges do not share a common times series, nor are all time series of the same length; still, the time series correspond to periods of not greater than minor impact on the hydrology of the corresponding catchments.

From this data, criteria and thresholds were identified, in addition to the ones mentioned above for the P and E types, by interpretation of corresponding box plots (Appendix 2), without consideration whether the differences between stream types visible on the box plots are statistically significant. Several combinations of thresholds and weights were tried and their results compared to river types, using the percentage of misclassifications in each river type as criterion. Weights were applied to the criteria, giving higher weights to statistically significant criteria that had been identified in step 2 above. This process led to the final set of criteria and thresholds that have wider applicability but include thresholds with reduced statistical significance.

Catchment characteristics used were mean catchment elevation, precipitation, catchment slope, stream slope and catchment geology; the corresponding criteria and thresholds are given in Table 5 below. The criteria were applied using a multi-criteria procedure on the river reach scale. For each subcatchment/stream reach, each parameter of Table 5 was evaluated according to the thresholds, and the stream type that corresponds to the numerical value of the parameter was noted. This was done for each parameter and then the number of indications for each stream type was summed up, for each subcatchment/stream reach, taking into account the weights. The stream type with the most indications was assigned to the stream reach. In cases where two stream types had equal number of indications, the stream type was assigned by expert judgment.

The percentage of misclassifications when using this final set of criteria was estimated by comparison with river types calculated from stream flow monitoring data and for all types it was 46%. In detail, it was found to be 26% and 15% for P and E types, respectively, while I and Ih types had a higher portion of misclassifications (61% and 55%), which was to be expected for the intermittent types because of the reasons mentioned further above. Nevertheless, the low percentage of misclassifications of E-type rivers is important because the separation of these streams from the intermittent streams, i.e. types I and Ih together, was a main objective of this study due to the importance for BQE monitoring.

Mediocre predictions for catchments without measured data are, on the other hand, not a rare phenomenon in the field of hydrology because making predictions in ungauged drainage basins often stalls on the unexplained dissimilarities of apparently similar basins (Kirkby et al., 2011). Misclassification rates as the ones reported above from the present study seem to be not uncommon. Mackay et al. (2012) had used a vegetation index to spatially extrapolate Australia's low-flow hydrological classification to generate a map and reported 50% misallocation rate. Again in Australia, Kennard et al. (2008) had used various sets of geographic and environmental variables to discriminate between flow regime classes and reported the percentage of flow gauges correctly allocated to their a priori flow regime to be 37.2% to 62.4%, thus misclassifications were between 37.6 and 62.8%. In France, the intermittence classification performed by Snelder et al. (2013) on intermittent rivers across France had an overall misclassification rate of 46%. Concluding from the above, the 46% overall rate of misclassification found in this study is of the same magnitude as similar studies including temporary rivers, in other dry regions of the globe.

<u>*Step 4*</u>

As final step, comprehensive inspections of the assigned stream types were undertaken. Stream type assignments were checked for plausibility, especially to ensure a "correct" upstream to downstream succession of flow regimes, from perennial to ephemeral. In addition, a number of experts with local knowledge were consulted for their experience regarding flow regimes in specific rivers. These resource persons greatly improved stream type assignments; they were adding the field verification and the knowledge of the small-scale processes that determine flow intermittence in the sense of (Hansen, 2001) and Snelder et al. (2013). During this process, necessary adjustments to the stream reaches' extent were also carried out, adjusting stream type transitions by taking into account local geology, vegetation patterns, topography, etc. but also in some cases the boundaries of the river water bodies of the first RBMP.

Table 5 : Criteria (parameters, thresholds and weights [W]) used for the assignment of TSR types based on catchment characteristics.

River type	P	I	Ih	E
Parameter	**Thresholds and weights**			
Mean catchment elevation [m amsl]	>=850 W=1	700-850 W=1 500-700: I OR Ih, W=0.5	400-500 W=1 500-700: I OR Ih, W=0.5	<=400m W=1
Precipitation over catchment (1971-2000) [mm]	>=670 W=2	550-670 W=1 510-550: I OR Ih, W=0.5	470-510 W=1 510-550: I OR Ih, W=0.5	<=470 W=1
Mean stream slope [degrees]	>=5 I OR P W=0.5	>=5 I OR P W=0.5	3.5-5 W=1	<=3.5 W=2
Mean catchment slope [degrees]	>=17 I OR P W=0.5	>=17 I OR P W=0.5	11-17 W=1	<=11 W=1
Troodos Ophiolite rocks (coverage of catchment)	Not less than 70% W=0.5	Not less than 70% W=0.5	-	-
Circum-Troodos Quaternary & Sedimentary (coverage of catchment)	Not more than 30% W=0.5	Not more than 30% W=0.5	-	-
Troodos mantle and plutonic rocks (coverage of catchment)	>=0.61 W=1	-	-	-

The approaches described in the steps above were applied in a tiered procedure, assigning stream types using the most reliable and certain criteria first, in all reaches possible, and then proceeding to apply criteria with increasing uncertainty, until all reaches are classified. The tiered approach included the following:

Tier 1:

Tier 1 corresponds to step 1 described above, as confirmed by step 2. Assignment of river types to reaches that have their stream type determined from gauging station data within the reach, and where this stream type matches the type as determined from the first set of criteria mentioned above. This set of criteria corresponded to P and E types only and 19 reaches were assigned their river type by this method.

Tier 2:

Tier 2 corresponds to step 1 described above. Assignment of river types to reaches with stream type determined from a gauging station within the reach. 57 reaches were assigned their stream type by this method; 48 of them correspond to the intermittent types for which no criteria could be determined for tier 1 and four cases correspond to spring fed perennial streams that cannot be predicted by catchment characteristics.

Tier 3:

Tier 3 corresponds to step 3 described above. Assignment of river types to river reaches based on their catchment characteristics only, by applying the second set of criteria and thresholds mentioned in Table 5 above using a multi-criteria procedure on the river reach scale. In this way the remaining 148 river reaches were classified; finally, 15 of the 148 reaches needed expert judgement to assign the final type, because the multi-criteria procedure had yielded ambiguous results.

Tier 4:

Tier 4 corresponds to step 4 described above. The final inspections of the types assigned to the river reaches were undertaken catchment by catchment and included two sets of inspections.

The first set of inspections revealed that some reaches had to be split and led to an increase of the stream reaches from 232 to 250. Splitting was necessary e.g. where a reach had been very large due to the large historic subcatchment on which it was based, and due to its large size it turned out to include more than one stream type. A typical case of very large historic subcatchments is the Peristerona catchment. In 29 of the 250 reaches the stream type assigned in tiers 1-3 was changed. The necessity to adjust stream types arose mainly when the river type assigned to a reach in tiers 1 or 2 (i.e. based on available flow data) indicated that the flow regimes in neighbouring upstream and downstream reaches are different than the river type worked out from catchment characteristics (tier 3). In the same sense, such necessity also arose in some cases in order to ensure a “correct” upstream to downstream succession and/or transition of flow regimes, from perennial to ephemeral.

After the above first set of inspections, adjacent reaches of same type were joined leading to a stream network of 184 river reaches with river types assigned to each reach.

The following second set of inspections involved checks of all 184 river reaches in close cooperation with retired WDD hydrologist Christos Ioannou. Every catchment and reach was thoroughly evaluated, checking the types assigned by the tiered approach described above against the extensive field knowledge of Mr Christos Ioannou; in the course of these inspections, a number of other persons were contacted for their local knowledge of flow characteristics in specific catchments. This last inspection step led to changes to 12 river reaches; some refer to changes of the initially assigned type due to overriding local conditions (e.g. significant influence of springs) while other refer to changes in the spatial extent of reaches of a certain TSR, but no reaches were split or merged thus retaining the number of reaches at 184. It is clear that these final adjustments cannot be regarded as an absolutely exact process, especially in the intermittent river types where stream flow shows a large inter-annual variation that is creating huge temporal variability of the flow period's length at a given point along the river.

3.1.5 Water body delineation

Methodological considerations

Sub-component (4) is a pure data combination process and no specific research questions are related to it.

The approach to the segmentation of rivers and river networks as described by the relevant CIS Guidance Document (European Commission, 2003a) needed to be taken into account for sub-component (4) "Water body delineation", which was based on the new typologically classified river network and on pressures respectively pressure groups.

Implementation – project activity

This step of the procedure is the delineation of the WFD management units, i.e. the water bodies, using as basis the 184 typified river stretches that were elaborated in the previous parts of the project.

According to WFD CIS Guidance Document No. 2 (European Commission, 2003a, p.2), a water body should be a coherent sub-unit in the river basin (district) to which the environmental objectives of the directive must apply. Hence, the main purpose of identifying "water bodies" is to enable the status to be accurately described and compared to environmental objectives. This implies that it should be possible to apply unambiguous and measurable environmental objectives, defined in the terms prescribed by the WFD, to each water body.

Based on the abovementioned Guidance Document No. 2 (European Commission, 2003a, p.11), the following steps should be followed for water body delineation:

1. Delineate surface water categories (cf. chapter 3.1.2)
2. Sub-divide surface water categories into types (cf. chapters 3.1.3 and 3.1.4 above)
3. Sub-divide types according to significant natural physical features
4. Sub-divide physical divisions according to other criteria such as: difference in status; or the extent of Protected Areas
5. Identify as non-HMWB or identify as HMWB

The Guidance Document suggests implementing the above steps in an iterative way (European Commission, 2003a, p.11), utilizing information from WFD Annex II 1.5 risk assessments and Article 8 monitoring programmes for verification and refinement of the delineated water bodies.

Steps 1 and 2 above were covered by previous chapters. In addition, step 3 was largely covered by the work described in chapter 3.1.4 because the typified reaches were elaborated based on the historic Cyprus subcatchments. The latter had been delineated by the Water Development Department (Toufexis et al., 1970) based on hydrological and hydrogeological criteria largely corresponding to exactly the "significant natural features" required by the Guidance Document (e.g. confluences). Therefore, no specific efforts were devoted to further subdivision of reaches according to natural features at this stage of the work; nevertheless, when reaches were split into water bodies and as a general approach, natural features were taken into account wherever possible.

With respect to the water bodies that cross the so-called Green Line into those areas of the Republic of Cyprus in which the Government of the Republic of Cyprus does not exercise effective control, no splitting or else was applied at the Green Line. According to the provisions of Article 1 of Protocol No 10 on Cyprus, attached to the Treaty of Accession to the EU, the application of the acquis is suspended in those areas of the Republic of Cyprus in which the Government of the Republic of Cyprus does not exercise effective control. Nevertheless, some water bodies happen to change type close to the Green Line and, consequently, they end/start near the Green Line for that reason.

The suggestion for iterative verification and refinement of the delineated water bodies was followed through consideration of corresponding recommendations from the first RBMP, of draft data from the status assessment for the second RBMP and of other information (e.g. pressures) collected during the implementation of the first RBMP. This corresponds to point 4 above and was implemented in a procedure of four loops, each loop representing inspections of all catchments corresponding to WFD streams as identified in previous chapters. Finally, the identification of the HMWBs was added as a fifth loop, and the steps that were followed are:

1. Consideration of recommendations from the first RBMP
2. Consideration of pressures and monitoring data
3. Checks for difference in status
4. Consideration of protected areas
5. Identification of Heavily Modified Water Bodies (HMWBs)

Consideration of recommendations from the 1st RBMP

Eleven such recommendations were identified by Karavokyris & Partners Consulting Engineers S.A. and Kaimaki (2011a) and by Karavokyris & Partners Consulting Engineers S.A. and Kaimaki (2009). Some were found clearly stated in writing while others were indirectly suggested in the text. All 11 recommendations were finally adopted, but it was noticed that several of them had already been implemented by applying the typology (cf. chapter 3.1.4), in particular because many reaches were starting and/or ending at major natural physical features e.g. junctions.

Consideration of pressures and monitoring data

To account for all pressures, it would have been necessary to evaluate the pressure information for deciding whether a river reach needs to be split in order to allow for “accurately describing status and compare it to environmental objectives” (European Commission, 2003a, p.2). However, no objectively applicable criteria for such an evaluation were available, i.e. all decisions would need to be taken using expert judgement. Therefore, it was decided to limit the consideration of pressures to checks, on river reach level, for absence/presence of pressures with the aim of identifying reaches, or part of reaches, without pressures, and to separate them if monitoring data supports the decision. One reason for taking this approach was to keep the number of water bodies as low as possible. In addition, it was considered unwise to subdivide reaches exposed to several different pressures without knowing the impact of each of these pressures, as it was unknown where a pressure has significant impact and where not. On implementing the approach, Corine 2006 land use data (Department of the Environment, 2008) were used as first criterion, as recognition of the widespread impact of diffuse pressures from agriculture; if this criterion **did not indicate** a homogenous area without pressures, no further checks were done and the reach was not split. In cases where Corine 2006 land use data **did indicate** a homogenous area without pressures, all other available pressure information was evaluated as additional criteria to check whether the reach, or a significant part of it, is without pressures and would thus qualify to be split. Finally, such reaches were split only in cases where monitoring data confirmed the absence of pressures; still, identified reaches without pressures that were not separated due to absence of monitoring data were noted for future investigation. It is worth mentioning here that a number of the abovementioned recommendations from the first RBMP (Karavokyris & Partners Consulting Engineers S.A. and Kaimaki, 2011a, Karavokyris & Partners Consulting Engineers S.A. and Kaimaki, 2009) address issues of differences in pressures, which had all been implemented previously in loop (1), i.e. during the consideration of the recommendations from the first RBMP.

In cases, where monitoring data confirmed the impact of point pressures, reaches were split respectively kept as separate tributaries. Examples are the Garyllis River at the tributary from Vati waste site and Xylias River, a tributary of Treminthos river draining the area of the Sia mine.

Checks for difference in status

Status information was obtained from the final draft report on the classification of water status (ENVECO S.A. and I.A.CO Ltd, 2013), while pressure information was obtained from various sources (1st RBMP, data from various Governmental Departments, Corine land use data).

The river reaches that had resulted from the procedure so far, were checked individually for differences in status, in cases with more than one monitoring station; still, a conservative approach was adopted rather not splitting a reach if there is no convincing evidence that status would be different in the resulting water bodies.

The fact that the final *draft* report (ENVECO S.A. and I.A.CO Ltd, 2013), and not the final report, was used here corresponds to the remarks in WFD CIS Guidance Document No. 2 (European Commission, 2003a, p.12) upon the need to “ensure that a balance between an iterative identification and the final assignment of water bodies is achieved”, which is hinting at the circular references between water body status and its spatial definition and the fact that the “delineation of water bodies must be finally agreed at a certain point in time” in order to proceed with RBMP preparation.

Consideration of protected areas

The following types of protected areas were taken into account:

- SCI - "Sites of Community Importance" established under the Habitats Directive 92/43/EEC; only water related SCI areas were considered

- SPA - "Special Protection Areas" established under the Birds Directive 2009/147/EC
- NVZ – "Nitrate vulnerable zones", established under Directive 91/676/EEC
- UWW_SA – "Urban Waste Water Sensitive Areas", established under Directive 91/271/EEC

The above protected areas' extents were compared to the river reaches that had been delineated so far by the above process. Once again, an approach was adopted aiming to keep the number of water bodies as low as possible. To this end, additional water bodies would only be created in cases where they would also correspond to differences in pressures. Still, in the majority of cases, the boundaries of SCI and/or SPA areas coincide fully or at least largely with water body boundaries. In addition, there are cases where NVZ (Chrysochou) and UWW sensitive areas (Garyllis) coincide very well with water body boundaries.

Identification of Heavily Modified Water Bodies (HMWBs)

The review of the criteria for the identification of HMWBs and thus a new identification of HMWBs in the sense of the WFD was NOT part of this study; within this study, the 49 HMWBs designated in the first RBMP would again become HMWBs without any further consideration. In addition, HMWBs would be proposed for designation in streams added to the WFD river network by this study and also in natural water bodies of the first RBMP in cases where WBs were provisionally found to be substantially changed in character according to Article 2.9 of the WFD. Their final designation as HMWBs or not will be included in the elaboration of the second RBMP.

In addition to the above HMWBs, 15 water reservoirs also became river HMWBs as type "impounded rivers". These correspond to the 11 water reservoirs that had been identified as lake water bodies for the first RBMP plus four water reservoirs that are added as water bodies for the second RBMP. The work related to the addition of the four water reservoirs to the WFD water body network was carried out in the framework of contract YY02/2013 (ENVECO S.A. and I.A.CO Ltd, 2013).

3.1.6 Elaboration of the water body coding scheme

New water body codes had to be assigned to the water bodies in order to avoid any mix-ups with the codes of the water bodies delineated for the first RBMP. This is especially important because the present study created geometrically new water bodies; consequently, even corresponding streams of the first RBMP and the second RBMP are not congruent. The aim of the new water body coding system is to make the codes unmistakably distinguishable from the system used in the first RBMP.

It was aimed that by seeing a Cyprus river water body code one can immediately recognize whether it is a water body delineated for the first or the second RBMP. Other objectives for the new coding system were: to avoid mix-ups of WB codes with the historic Cyprus subwatershed codes, which was not ensured with the 2005 coding system; to retain the historic Cyprus catchment codes (e.g. 1-1, 1-2, etc.; Toufexis et al., 1970) as component of the WB codes; to include river type and HMWB indication as part of the code and also to allow for effective and meaningful sorting by the WB code in tables, data bases etc. In order to avoid mix-ups with the subcatchment codes (e.g. 1-1-1, etc.), a letter is used to distinguish the water bodies within each catchment (e.g. 1-1-a, 1-1-b, etc.). The new coding system for Cyprus' river water bodies covers impounded rivers (i.e. water reservoirs) too, as these are being considered as HMWB rivers for the second RBMP. In order to achieve the above requirements, the code consists of the concatenation of:

- Country code "CY"
- Historic catchment code e.g. "1-1", "1-2", etc.
- A small letter, starting in each catchment with "a" and being assigned according to a defined procedure to all water bodies within a catchment
- The letter "R" for "River", followed by the river type abbreviation, yielding RP, RI, RIh, RE
- Indication of a HMWB by "HM", where this applies
- Indication of an Impounded River by "IR", where this applies
- The above components are separated by an underscore "_"; only the catchment code (e.g. 1-1, 1-2, etc.) and the small letter designating the water body are separated by a hyphen "-".

With respect to the small letter that distinguishes the water bodies within each catchment, the following procedure of assignment was followed. The small letters were assigned starting from the main (highest) headwater stream and then proceeding downstream to the river mouth. The water bodies along the main stem were assigned first, from the main headwater stream to its mouth; then the remaining tributaries were assigned, proceeding again from the headwaters to the river mouth. In cases with equivalent major tributaries above major confluences (e.g. the three Kouris tributaries upstream of Kouris Dam), these major tributaries were assigned codes first in a clockwise direction around Troodos summit, finishing each major tributary before proceeding to the next; then the numbering proceeded downstream of their junction towards the river mouth. For the decisions which streams are "equivalent major tributaries" the historic subcatchment codes were consulted. In cases with more than one river mouth per historic catchment code (e.g. catchments 1-5, 2-3), numbers/letters were assigned to each separate river, finishing each river before proceeding to the next, and proceeding from one river to the next in a clockwise direction around Troodos summit.

With respect to the names of the stream sections that make up the water bodies, a number of maps that were available in the geodatabase of WDD in digital format was consulted, e.g. topographic maps at scale 1:50,000 (Directorate of Military Survey, 1972), 1:25,000 (Directorate of Overseas Surveys, 1960), 1:5,000 (Department of Lands and Surveys, 1982) and two inches to one mile, as well as cadastral maps at various scales (1:5,000, 1:2,500, 1:1,1250). For few streams no name could be found in any of the above maps, and these cases remain nameless.

The corresponding river names in Greek were located in the "complete gazetteer of Cyprus" (Christodoulou and Konstantinidis, 1987) and appended to each water body.

3.1.7 Elaboration of the water body grouping scheme

Methodological considerations

For sub-component (5) "Elaboration of the water body grouping scheme", which will take into account the pressures acting on the rivers and catchments and that will contribute to improved water status assessment procedures for unmonitored water bodies, the relevant research question is "What are the significant pressures and/or pressure groups acting on Cyprus riverine systems, and how are they spatially distributed?" I.e., there is first the question which pressures need to be considered and once these are decided upon, their spatial aspect needs to be determined. The next step is to group pressures to form typical multi-pressure situations.

The most important constraint for sub-component (5) was the availability of data on the pressures. In addition, comments by COMM on the first Cyprus RBMP had to be considered too (European Commission, 2012).

As far as data capture is concerned, the project relied largely on data that could be retrieved from existing sources and the format of available data was an important issue; both of these issues are crucial because in the timeframe of the project neither collection of primary data nor extensive digitization of data was possible. All the information was analyzed and drawn together in a Geographic Information System (GIS).

This study proposes a completely new river typology and river water body network (cf. chapters 3.1.2 - 3.1.5 above). This radical change in the system of river management units renders useless the groups of water bodies that had been established by WL | Delft Hydraulics et al. (2008) that had been mentioned in chapter 2.2.4. Consequently, a new water body grouping exercise was necessary to establish groups of the water bodies that had been elaborated in the present study, for the purpose of the assessment of status for the second RBMP.

The aim of the establishment of groups of water bodies, in the context of this study, is to enable the prediction of the status of unmonitored WBs with the data collected in monitored WBs. The general idea was to group the water bodies into groups of similar pressure levels, while keeping the river types separate, as suggested by the European Commission (2003d, p.12). This approach would yield groups of water bodies with similar pressure levels within each river type, and would enable to predict and assign water body ecological status to the WBs that are not being monitored, using the data from the monitoring stations within each group. Most attention was paid to the definition of the pressure level that corresponds to the critical boundary between good and moderate status, because this boundary separates the WBs achieving the WFD's environmental objectives from the WBs failing the objectives, and thus separates those WBs where management measures for the improvement of status are needed from the rest. In addition, the boundary between high and good status was estimated where possible.

Implementation – project activity

Identification of important pressures and corresponding pressure characteristics

The first step in this exercise was to examine the available monitoring and water status data in order to identify the quality elements (QEs) leading to failure to achieve good status. The analysis of the draft final status assessment results that will inform the second RBMP (ENVECO S.A. and I.A.CO Ltd, 2013) yielded the following results:

- 20 out of 61 stations monitored for biological quality elements fail the biological objectives set for WFD implementation in Cyprus. Out of these 20 stations, 12 had been assessed for both macroinvertebrates and phytobenthos (diatoms) and from these, nine were failing due to invertebrates, one due to diatoms and in two stations both BQEs failed the biological objectives. In most stations failing the biological objectives, the decisive BQE are benthic macroinvertebrates. While this BQE is well known to respond to organic pollution (e.g. European Commission, 2003d, p.38), the specific index applied in Cyprus does also respond to catchment land use, flow modification, general degradation, habitat destruction, hydromorphological degradation and riparian habitat alteration (Birk et al., 2010).

- Out of 63 stations monitored for physico-chemical parameters, 22 stations failed the objectives set for physico-chemical parameters. Out of these 22 stations, 19 stations on 10 rivers failed the objectives due to elevated nitrate concentrations, indicating the large impact of nitrogen fertilizers on river systems.

Having identified the potentially important pressures from the analysis of the monitoring results, the next step was to search for available data, or suitable substitute data (proxies), which would allow quantifying the respective pressure levels of all 230 river water bodies. It is worth noting that all river water bodies must be characterized because the pressure levels will subsequently be used to categorize each single water body into its group; consequently, only pressure data that covers the catchments of all 230 water bodies is suitable for this undertaking. While seemingly obvious, it is still worth to recall that the mere existence of suitable pressure data is decisive for the grouping exercise to proceed. Without suitable data on the potentially important pressures, attempts to predict the status of unmonitored water bodies using water body groups as suggested by WFD CIS Guidance Documents no. 2 and no. 7 seem destined to fail.

After an investigation for available information it was decided to use the parameters (pressure characteristics) and corresponding pressures shown in Table 6.

Table 6: Parameters and corresponding pressures used for the elaboration of the water body grouping scheme

Pressure characteristic	Pressures addressed
Population density	organic pollution, land use, general degradation; to a lesser extent habitat destruction, hydromorphological degradation and riparian habitat alteration
Livestock annual Nitrogen load	organic pollution, general degradation
Areas of “intensive agriculture”, assumed to be largely irrigated	fertilizers, land use, general degradation; to a lesser extent habitat destruction, flow modification, hydromorphological degradation and riparian habitat alteration

It is evident that the three selected pressure characteristics cover a wide range of pressures, including most of the pressures detected by the quality elements leading to failure to achieve the environmental objectives of the WFD mentioned above. In detail the following data was used for each pressure characteristic:

- Population density: Census 2011 (CYSTAT, 2013) combined with CORINE 2006 level 2 class 11 “urban fabric” (Department of the Environment, 2008). The CORINE “urban fabric” polygons had to be used to determine the population within each catchment, in cases where a village or municipal area extends over more than one catchment. This was especially important in highly populated municipal areas in the large cities; nevertheless, the approach also contributed to a better representation of the true distribution of the population in the mountainous part of Cyprus. An interesting insight from this analysis is that more than 35% of the island's population (excluding those areas of the Republic of Cyprus in which the Government of the Republic of Cyprus does not exercise effective control) are living outside WFD river water body catchments; this is mainly due to the large agglomerations on the coast and the populous villages in the flat Kokkinokhoria area in the southeast of the island, which are largely outside of river water body catchments. It is also interesting to note that from the population of 520.000 people within water body catchments, about 250.000 are in the Greater Nicosia area.

- Livestock annual Nitrogen load: animal number per livestock unit combined with indicative loads per animal (Defra, 2009); animal number and livestock units data for 2013 had been provided in geo-referenced format by the Cyprus Veterinary Services to the WDD; the load values were selected based on assumptions of best fit to Cyprus conditions and are shown in Table 7.

Table 7: Livestock annual Nitrogen load values used for elaboration of water body grouping scheme

Livestock	kg N/year
1 Cattle	100
1 Pig	90
1000 Poultry	450
1 Sheep/Goat	11

- Areas of "intensive agriculture" (portion of the catchment/buffer), assumed to be largely irrigated. The assumption is that more or less permanently irrigated land leads to leaching of fertilizers into (shallow) groundwater and then into surface water courses. The Corine level 3 categories (Department of the Environment, 2008) that were considered to represent "intensive agriculture" are shown inTable 8.

Table 8: Corine level 3 categories considered to represent "intensive agriculture"

Corine level 3 code	Land use category
212	Permanently irrigated land
222	Fruit trees and berry plantations
241	Annual crops associated with permanent crops
242	Complex cultivation pattern with scattered houses
243	Land principally occupied by agriculture, with significant areas of natural vegetation

Quantification of pressure intensity on water body level

In the next step, the abovementioned pressure characteristics had to be determined for each water body and the spatial scale for this task had to be decided upon. From the literature review (cf. chapter 2.2.4) it was concluded that it is prudent to investigate both the catchment and the buffer level. Later on, the results from both spatial levels would be compared in order to decide which approach yields the clearer relationship with the water bodies' status.

The catchments of the water bodies were created without overlaps, to form areas that contribute exclusively to each outlet in the sense of the "exclusive contribution zones (ECZs)" described by Maillard and Pinheiro Santos (2008, p.163); only catchments of headwater water bodies reach up to the water divide, while "intermediate" water bodies located further downstream along the river's course encompass only the area between the respective inlet and outlet of the water body.

Regarding the suitable widths of buffers to be used, the literature review had not yielded clear suggestions (cf. chapter 2.2.4); still, the few quantitative indications from the studied papers were taken into account and in combination with a review of the WFD rivers delineated in this study, the corresponding river valley widths and the location of pressures in the catchments the buffer widths to be applied were set. From the review of the catchments, it was quickly realized that the situation in narrow headwater valleys with steep slopes is quite different from middle and lower reaches in wide valleys. Taking into account the corresponding stream orders, it was decided to apply different buffer widths for streams of order up to 4 and for larger streams of order 5 and above. After initial trials and visual assessment of the results, the final buffer widths were set to 200m on each side of the river for streams up to order 4, and to 400m on each side of the river for streams with order greater than 4. For the creation of the buffer areas around each water body, the 2nd order stream network was used as basis, thus considering also small streams that were not delineated as water bodies but are still contributing to the main rivers. The buffers created for each water body catchment correspond to what was termed “riparian zones (RZs)” by Maillard and Pinheiro Santos (2008, p.163).

As regards the grouping of heavily modified water bodies (HMWBs), it was decided to place them into groups of the river type that correspond to their current hydrological regime; to this end, their current river type was determined from available data of the hydrologically impacted period. This approach seems justified based on WFD CIS Guidance Documents no. 4 on Heavily Modified Water Bodies (European Commission, 2003c, p.20), which states that Maximum Ecological Potential, i.e. the reference condition, has to be determined based on the “closest comparable surface water body” that in the present case would be a river with respective hydrological regime.

In this analysis only HMWBs in good or better status were included. This approach is justified by the fact that these water bodies could be de-designated, from HMWB to natural water bodies, for the 2nd RMBP based on the HMWB designation procedure of WFD CIS Guidance 4 (European Commission, 2003c, p.20). Still, the above approach was not applied to type E water bodies; due to the scarcity of data, it was decided not to exclude any catchments of type E from the analysis, as this would have rendered the threshold analysis for river type E impossible. While certainly not ideal, this approach seems justified by the fact that these rivers do already correspond to the “driest” river type defined in this study. Therefore, they cannot change into a type of even more reduced stream flow, i.e. even greater hydromorphological alteration, due to flow alteration. This fact on the other hand indicates the large variation of stream flow regimes included within the rivers of type E.

Having completed the abovementioned preparations, the three pressure characteristics were determined for all water body catchments and buffers.

<u>Identification of ecological status’ responses to pressures</u>

For the water bodies with available monitoring data, the pressure characteristics were related to the water bodies’ ecological status as given in ENVECO S.A. and I.A.CO Ltd (2013) and are graphically represented on box plots shown in Appendix 3. On the box plots, a visual assessment was made whether there is a relation between the pressure level and the ecological status and whether thresholds of pressure levels between the status classes can be identified. A “relation between the pressure level and the ecological status” means that with varying (increasing) pressure level, a change in ecological status (towards the worse) can be observed.

Subsequently, the data sets for P and I types were tested for differences between status classes, separately for each pressure characteristic and by river type; the data sets for types Ih and E were not tested due to the very small number of data points – there are only six cases in each of these types. The data sets of the P and I types were first visually assessed on histograms and quantile-quantile plots (q-q plots) and subsequently they were tested for normality applying the Kolmogorov-Smirnov test with Lilliefors criterion and the Shapiro-Wilk test. The null hypothesis of normality had to be rejected in all cases for the two types, on the alpha=0.05 level. Because the data cannot be considered to follow the normal distribution, a nonparametric test has to be applied to test for differences between status classes of the P and I type. The Kruskal-Wallis (KW) test was used for this purpose. The data had been arranged in three status classes: High (H), Good (G) and Moderate-Poor-Bad (MPB), where the latter corresponds to all sites (within each river type) of moderate or worse status, joined in one group. Statistical tests were performed using the software Statistica 10. The results of the tests are shown in the Table 9.

Table 9: Results of Kruskal-Wallis (KW) tests for differences between status classes, for P and I river types, separately for each pressure characteristic and by river type

Pressure characteristic	**River type**	**Differences between status classes Catchment level**	**Differences between status classes Water Body buffer level**
Population density	P (n=16)	KW-H(2,16) = 4.84, p=0.089	KW-H(2,16) = 4.84, p=0.089
	I (n=22)	KW-H(2,22) = 5.35, p=0.069	KW-H(2,22) = 4.62, p=0.100
	Ih	-	-
	E	-	-
Livestock annual Nitrogen load	P (n=16)	KW-H(2,16) = 3.98, p=0.137	KW-H(2,16) = 5.11, p=0.078
	I (n=22)	KW-H(2,22) = 8.04, **p=0.018**	KW-H(2,22) = 5.26, p=0.072
	Ih	-	-
	E	-	-
Areas of “intensive agriculture”, assumed to be largely irrigated	P (n=16)	KW-H(2,16) = 7.09, **p=0.029**	KW-H(2,16) = 7.84, **p=0.020**
	I (n=22)	KW-H(2,22) = 9.72, **p=0.008**	KW-H(2,22) = 6.68, **p=0.035**
	Ih	-	-
	E	-	-

The null hypothesis of the KW tests above is that the median values of the pressure characteristics are equal over the three status classes. With 2 degrees of freedom (3-1=2), the critical value of H, approximated from the chi-square distribution and for alpha=0.05, is 5.99. In cases where KW-H values are greater than the critical value of H, the null hypothesis must be rejected.

Based on the above criterion, there is statistically significant evidence that there is:

1. a difference in the level of "intensive agriculture" amongst the status classes, for both tested river types and on both spatial levels
2. a difference in the level of "Livestock annual Nitrogen load" amongst the status classes, at the catchment level for type I

Considering further the critical value of H with 2 degrees of freedom for alpha=0.1, which is 4.61, it becomes clear that there is marginally statistically significant evidence for:

1. a difference in the level of "population density" amongst the status classes, for both tested river types and on both spatial levels.
2. a difference in the level of "Livestock annual Nitrogen load" amongst the status classes, at the buffer level for both tested river types

The above results show that for all three pressure characteristics, for river types P and I and at least on the alpha=0.1 level, there is statistically significant evidence of difference amongst the status classes.

Still, the Kruskal Wallis results do not reveal which status classes are different. To find out, Mann-Whitney U tests were performed between the status classes, and Bonferroni corrections were applied to account for the increased likelihood of type I error (i.e. rejecting the null hypotheses when it is true) when doing the multiple comparisons. In the case of the P type, there are two hypotheses that need to be tested (H vs. G and G vs. MPB) and the alpha values to compare each hypothesis become:

- adopting an overall alpha of 0.1, for each single test the alpha=0.1/2=0.05
- adopting an overall alpha of 0.05, for each single test the alpha=0.05/2=0.025

For type I, the high status class has only one case (no test including H class possible), and thus the only pair to test is G vs. MPB, and therefore the alpha value need not be adjusted by a Bonferroni correction.

The results of the Mann-Whitney U tests are given in Table 10 below. Results that are significant at an overall alpha level, i.e. after applying the Bonferroni correction, of 0.05 are marked in **<u>bold underline</u>**, while results marginally significant at an overall alpha level of 0.1 are marked **bold**.

Table 10: Results of Mann-Whitney U tests for differences between status classes, for P and I river types, separately for each pressure characteristic and by river type

Pressure characteristic	River type	Differences between status classes Catchment level	Differences between status classes Water Body buffer level
Population density	P	H vs. G, p=0.42 G vs. MPB, p=0.14	H vs. G, p=0.42 G vs. MPB, p=0.14
	I	G vs. MPB, **p=0.056**	G vs. MPB, **p=0.074**
Livestock annual Nitrogen load	P	H vs. G, p=0.42 G vs. MPB, p=0.18	H vs. G, p=0.87 G vs. MPB, **p=0.045**
	I	G vs. MPB, <u>**p=0.011**</u>	G vs. MPB, p=0.054
Areas of "intensive agriculture", assumed to be largely irrigated	P	H vs. G, p=0.19 G vs. MPB, **p=0.045**	H vs. G, p=0.05 G vs. MPB, p=0.061
	I	G vs. MPB, <u>**p=0.006**</u>	G vs. MPB, **p=0.032**

After applying the Bonferroni corrections, statistically significant differences at alpha = 0.05 were detected between the G and MPB status class groups of the I river type for the livestock and agriculture pressures at the catchment level. For the P river type, marginally statistically significant differences at alpha = 0.1 were detected between the G and MPB status class groups for the livestock pressure at the buffer level and for the agriculture pressure at the catchment level. For the population density pressure, marginally statistically significant differences at alpha = 0.1 were detected for the I river type and on both spatial levels, while for the P river type no such difference could be found; still, the box plots show a distinction between the H and MPB status class groups for the latter and it is, therefore, even though with higher uncertainty, possible to use these results too. In general, clearer differences were found for the I type than for the P type, indicating that the final results for the I type will be less uncertain than the ones for the P type.

The above results were first used to choose the spatial level to be used for further analysis. The finally chosen spatial levels are given in Table 11 below, together with the results for the Ih and E types that are deemed useable for the purpose of water body grouping.

Table 11: Spatial levels (catchment, buffer) selected for further analysis, separately for each pressure characteristic and by river type

Pressure characteristic	River type			
	P	I	Ih	E
Population density	Catchment	Catchment	-*	expert judgement – catchment level
Livestock annual Nitrogen load	Buffer	Catchment	expert judgement – buffer level	expert judgement – buffer level
Areas of "intensive agriculture", assumed to be largely irrigated	Catchment	Catchment	Buffer	-*

*) These pressures are not used for the grouping of the water bodies of this type. The exception are those water bodies where the specific pressure does not exist, i.e. there is either zero population (for the Ih type) or no areas of "intensive agriculture" (for the E type) in the area. In the former cases, the specific pressure level was considered negligible, allowing setting the respective pressure level of these water bodies.

Thresholds of pressure intensities corresponding to ecological status classes

Subsequently, numerical thresholds were calculated for the types and spatial levels indicated in the table above (except the "expert judgement" cases), based on the box plots as follows:

- thresholds were determined for both the H-G and the G-MPB boundaries; the three status classes were considered to correspond to negligible, minor and important pressure levels
- If the upper quartile (75% percentile) of the good class corresponds to higher pressure than the lower quartile (25% percentile) of the moderate class (i.e. if there is overlap of the boxes on the box plot), then the minor/ important threshold would be set halfway between the upper quartile of the good class and the lower quartile of the moderate class, by simple averaging.
- If the lower quartile (25% percentile) of the moderate class corresponds to higher pressure than the upper quartile (75% percentile) of the good class, then the minor/important threshold will be set at the lower quartile (25% percentile) of the moderate class.

For the Ih and E types, the few available data did not allow to calculate thresholds except in one case (agriculture for Ih type). Still, thresholds had to be established for accomplishing the task of water body grouping. The negligible/minor thresholds were set at 0 (zero) thus putting only water bodies without pressure in the “no pressure” group. For setting the critical minor/important thresholds, initially the box plots were examined to visually assess the data situation and it was decided to set the thresholds at the 75% percentile of the Good status sites.

The final thresholds are given in Table 12 below. Because the numerical thresholds correspond to different spatial levels that are not directly comparable between each other, the spatial level is indicated with each threshold.

Table 12: Thresholds of pressure intensities corresponding to pressure levels (negligible, minor, and important), separately for each pressure characteristic and by river type. Spatial level: (c)=catchment level, (b)=buffer level.

Pressure characteristic	**Threshold between pressure levels**	**River type**			
		P	**I**	**Ih**	**E**
Population density [inhabitants/km^2]	Negligible /minor	0 (c)	0 (c)	-*	0** (c)
	Minor/important	14.1 (c)	16 (c)	-*	1100** (c)
Livestock annual Nitrogen load [kg N/yr/km^2]	Negligible /minor	1.9 (b)	0 (c)	0** (b)	0** (b)
	Minor/ important	6.2 (b)	569 (c)	1800** (b)	4000** (b)
Areas of “intensive agriculture”, assumed to be largely irrigated [portion of area]	Negligible /minor	0.01(c)	0.007(c)	0** (b)	-*
	Minor/ important	0.225(c)	0.275(c)	0.317 (b)	-*

*) Pressure not used for the grouping of the water bodies of this type (see above for further description)

**) based on expert judgement

Using the above thresholds, each water body was classified into one of three pressure levels (negligible, minor and important) for each pressure characteristic. The pressure levels are presented on maps in Appendix 4.

<u>“Combined pressure indicator”</u>

Because each water body can only belong to one grouping category in the end, the categorizations according to the three pressure characteristics must be combined into a single “combined pressure indicator” (CPI) for each water body. To this end, numerical values were assigned to the three pressure levels. The numerical range from 0 – 3 was divided into three equal intervals and the midrange values, following a similar procedure described by Skoulikidis (2008), were assigned to the pressure levels as shown in Table 13 below.

Table 13: Numerical values assigned to the three pressure levels (negligible, minor, and important)

Pressure level	Range	Midrange value
Negligible	0-1	0.5
Minor	1.1-2	1.55 [(1.1+2)/2]
Important	2.1-3	2.55 [(2.1+3)/2]

Using the numerical pressure values of each pressure characteristic, the average pressure value was calculated for each water body, yielding the "combined pressure indicator" (CPI). The latter was then plotted on box plots for all water bodies with monitoring results, grouped by the ecological status classes. The box plots show a very good distinction for the P and I types, especially between the Good and Moderate-poor-bad status classes, and are shown in Figure 10; this distinction is clearer than for each separate pressure characteristic, indicating that the CPI predicts ecological status better than each pressure characteristic on its own, in the manner of a multi-metric index.

The data sets of the P and I types were subsequently visually assessed on histograms and quantile-quantile plots (q-q plots) and subsequently they were tested for normality applying the Kolmogorov-Smirnov test with Lilliefors criterion and the Shapiro-Wilk test. The null hypothesis of normality had to be rejected in all cases for the two types, on the alpha=0.05 level.

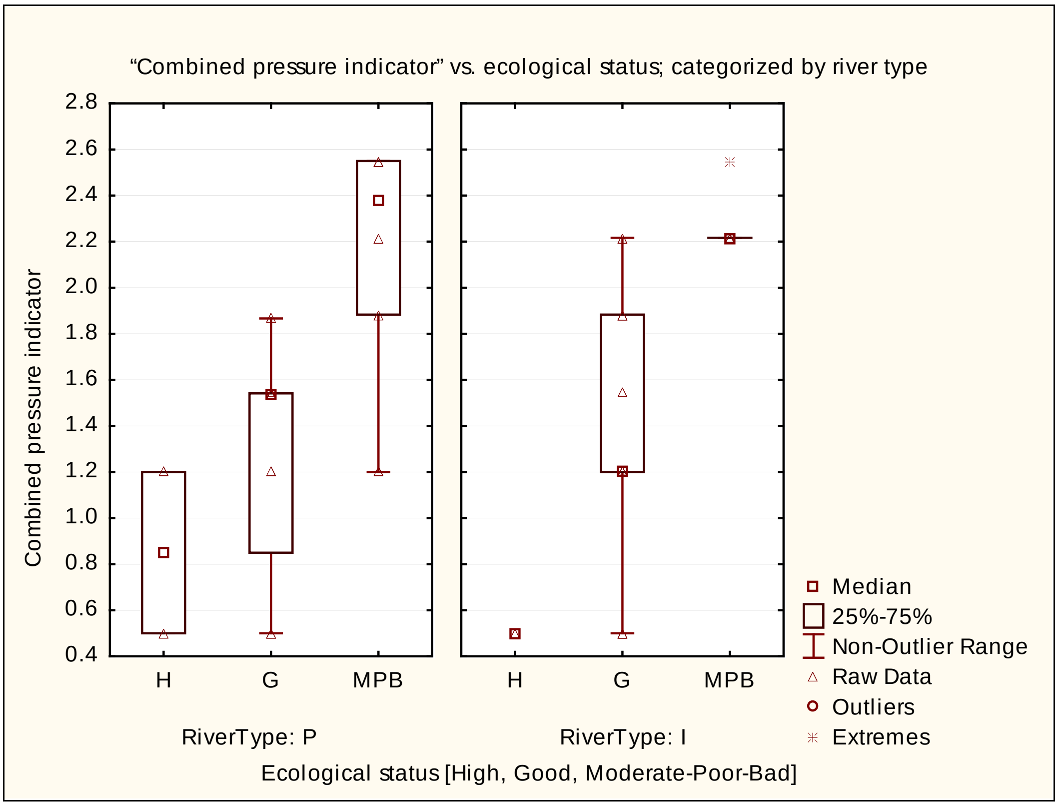
The datasets of the P and I type were tested for differences between status classes using the Kruskal-Wallis (KW) test. The data had again been arranged in three status classes: High (H), Good (G) and Moderate-Poor-Bad (MPB), where the latter corresponds to all sites (within each river type) of moderate or worse status, joined in one group.

The results of the KW test are:

- For the P type (n=16): KW-H(2,16) = 7.70, p=0.021
- For the I type (n=22): KW-H(2, 22) = 11.69, p=0.003

The null hypothesis of the KW tests above is that the median values of the combined pressure indicator are equal over the three status classes. With 2 degrees of freedom (3-1=2), the critical value of H, approximated from the chi-square distribution and for alpha=0.05, is 5.99. In cases where KW-H values are greater than the critical value of H, the null hypothesis must be rejected. Based on this criterion, there is statistically significant evidence that the median of the CPI is different amongst the status classes for both river types.

Figure 10: Graphs of the "combined pressure indicator" (CPI) vs. ecological status, categorized by river type



To find out which status classes are different from each other, Mann-Whitney U tests were performed between the status classes, and applying a Bonferroni correction to account for the increased likelihood of type I error (i.e. rejecting the null hypotheses when it is true) when doing the multiple comparisons. In the case of the P type, there are two hypotheses that need to be tested (H vs. G and G vs. MPB) and at an overall alpha of 0.05, the alpha value to compare each hypothesis becomes alpha=0.05/2=0.025.

For type I, the high status class has only one case (no test including H class possible), and thus the only pair to test is G vs. MPB, and, therefore, the alpha value need not be adjusted by a Bonferroni correction. The results of the Mann-Whitney U tests are given in Table 14 below.

Table 14: Results of Mann-Whitney U tests for differences in the "combined pressure indicator" (CPI) between status classes and by river type

River type	Differences in the magnitude of the "combined pressure indicator" between status classes
P	H vs. G, p=0.28 G vs. MPB, **p=0.019**
I	G vs. MPB, **p=0.0015**

For the P and I river types, statistically significant differences in the magnitude of the "combined pressure indicator" were detected between the G and MPB status class groups at alpha = 0.05. This result indicated that it is justified to use the CPI as index for the determination of pressure level thresholds that would subsequently be used for the categorization of the water bodies into assessment groups corresponding to minor and important pressure level; still, it was decided to determine thresholds for the distinction between negligible and minor pressure levels too, as on the box plots corresponding distinctions are evident. These latter thresholds will allow assigning water bodies into the "high" status class, which is considered important as it discriminates river reaches of "reference" quality with only negligible anthropogenic impact from the large number of water bodies in "good" status where anthropogenic impact, though still minor, is considerably greater.

From the box plots, thresholds of the indicator were then derived for the two river types P and I, corresponding to the High/Good and the Good/Moderate-poor-bad class boundaries of ecological status; the thresholds are shown in Table 15.

Table 15: Thresholds of the "combined pressure indicator" (CPI) between pressure levels and by river type

Pressure characteristic	Threshold between pressure levels	River type	
		P	I
Combined pressure indicator	Negligible /minor	1.0	0.5
	Minor/important	1.87	2.2

For the Ih and E type, due to the small number of data, thresholds for the CPI could not be determined. Instead, the water bodies of these two river types were assigned into the three pressure levels based on the thresholds of the pressure characteristics given in Table 12 above. The thresholds were applied as shown in Table 16 and Table 17 below.

Table 16: Thresholds and criteria of pressure characteristics for the three pressure levels applied to river type Ih

River type Ih	
Combined pressure level	**Thresholds / Criteria**
"negligible"	Areas of "intensive agriculture" (buffer level) = 0 and Livestock annual Nitrogen load (buffer level) = 0 kg N/yr/km^2
"minor"	All Water bodies that are neither "negligible" nor "important".
"important"	Areas of "intensive agriculture" (buffer level) >0.317 or Livestock annual Nitrogen load (buffer level) > 1800 kg N/yr/km^2

Table 17: Thresholds and criteria of pressure characteristics for the three pressure levels applied to river type E

River type E	
Combined pressure level	**Thresholds / Criteria**
"negligible"	Population density (catchment level) = 0 inhabitants/km^2 and Livestock annual Nitrogen load (buffer level) = 0 kg N/yr/km^2
"minor"	All Water bodies that are neither "negligible" nor "important".
"important"	Population density (catchment level) > 1100 inhabitants/km^2 or Livestock annual Nitrogen load (buffer level) > 4000 kg N/yr/km^2

3.2 Stakeholder consultation

The stakeholder consultation was conducted in parallel with the technical part and provided input to it, as is illustrated in Figure 1 further above.

The **objective** of this component of the project was to collect information on anticipated benefits and potential negative effects of the proposed new river typology, new river water bodies network and assessment groups. Therefore, the research question was "What are the anticipated benefits and potential negative effects of the implementation of the proposed new river typology, the new river water bodies network and assessment groups?" In parallel, the stakeholder consultation provided feedback for the development of the technical components of the DProf project.

With respect to **constraints** and the **practical framework**, one main point that had emerged from the literature review was the stakeholders' potential lack of knowledge of the rather technical subject (cf. chapter 2.3.6); such a lack of knowledge was also anticipated from my personal experience from interacting with the stakeholders on similar matters. In order to get them involved, it was necessary to inform them about the necessary technical details of the WFD to ensure that the stakeholders understand and can contribute to the process; only after this "introduction" I was able to proceed and explain to them the necessity to change the present river typology and water bodies network and the proposed changes. It was also anticipated that it could be difficult to get some stakeholders involved due to the anticipated small impact the proposed change will have on them (van der Heijden and ten Heuvelhof, 2012).

The **approach** could only be a subjective one, as I was presenting and discussing my own proposal. Therefore, it was especially important to maintain self-awareness of this fact at all times and to evaluate, in a reflexive way, the potential bias this fact introduced in my own acting during the process and also in my interpretation of the outcome during the analysis of the collected information.

Role ambiguity is an issue emerging from the very nature of the action research approach (Gill and Johnson 2002) and in the DProf project this is especially evident due to the my **role as practitioner-researcher**, which actually comprises dual roles (Middlesex University, 2011): one as a researcher and one as a hydrologist at WDD (cf. Chapter 1.1). My role as practitioner-researcher origins from the fact that my research is undertaken to inform practice, in the form of the new river typology and river water bodies network, through the practice of the project, which can be characterized as a development and change project (Middlesex University, 2011).

The **methodology** of the stakeholder consultation had to be appropriate to detect and describe the concerns of the stakeholders regarding the proposed change, in an as much as possible objective way, and an approach based on principles of action research seemed to be well suited for this purpose.

The term action research (AR) is used to cover a variety of approaches (Eden and Huxham, 2002) and it has been used to refer to a wide array of research activities, a fact that led Gill and Johnson (2002) to conclude that there is no unifying methodology of AR. Nevertheless, from a review of some pertinent textbooks (Blaxter et al., 2001, Costley et al., 2010, Gill and Johnson, 2002, Partington, 2002, Robson, 2002) it is possible to identify several features that are commonly mentioned as being characteristic of action research:

- Action research is change oriented
- Action research involves a planned intervention
- Action research is carried out in a cyclical process
- In action research, the participants are involved in the process

A definition of AR that does apply rather well to the setting of the DProf project is that it aims to making changes in a situation through a cycle or a set of cycles which follow the sequence planning - acting/creating change - observing/data gathering - reflecting/decision making (Middlesex University, 2011). The DProf project features an important variation to the common notion of action research described above because the intervention, i.e. the implementation of the new river typology, river water bodies network and grouping scheme, is not implemented in reality but rather in a virtual way, i.e. by exhaustively explaining it to the stakeholders. This “virtual action research methodology” is necessary as it is not possible to implement the intervention and then observe the stakeholders’ reaction because the time frame and especially the nature of the project do not allow it. This is admittedly a factor that possibly reduces the validity and reliability of the outcome of the stakeholder consultation in the sense of Eden and Huxham (2002, p.254) who support that "when subjects do not have to commit to real action and to creating a future which they will inhabit, any data gained from them are inherently unreliable". Such behaviour was reported in relation to WFD implementation in the Netherlands by van der Heijden and ten Heuvelhof (2012) who found that citizens do not see the need to participate actively in environmental issues as long as they do not directly affect them but that they start caring about such issues once they are implemented and impact on them. However, for the purpose of the DProf project, this shortcoming had to be accepted because it was impossible to implement the proposed change intervention in reality in the framework of the project; because the DProf project is embedded in the real time implementation of the WFD in Cyprus, the proposed intervention had to follow the time schedule as predefined by the text of the Directive.

An important feature of AR, with respect to the DProf project, is that the researcher can introduce concepts, which will in turn allow the participants to restructure their view on the researcher's systems model (Gill and Johnson, 2002). This indicates the important possibility to explain and describe the DProf's technical proposal to the stakeholders, which helped them to shape a more realistic picture of the impact the proposed change will have on them. This concept has special merit in the applied "virtual action research methodology" because the change will not be implemented in reality but needs to be explained to the stakeholders.

In the context of the DProf project, the action research cycle was planned to comprise the activities shown in Table 18 below.

Table 18: Activities of action research cycle (first cycle only is shown)

Step #	Activity
1	Establishment of proposal for new river network, new river typology, new river water bodies network and assessment groups ("Technical Part" of DProf)
2	Presenting and explaining the above to stakeholders
3	Collecting the views and comments of the stakeholders on the above
4	Analysis and evaluation of the views and comments of the stakeholders

After step 4 would be completed, another cycle would be undertaken, during which the views of the stakeholders would be used to amend the proposal and then the stakeholders would be given the opportunity to comment on the amended proposal. Two cycles as shown in Table 18 were carried out in total, i.e. the first proposal was to be amended, if necessary, after the first round of sessions and the amended proposal would be presented in a second round of sessions, from which the final comments and concerns were to be collected. Thus, the utilization of the collected information was twofold:

- firstly, it was feeding back into the ongoing development of the technical proposal and
- secondly, issues that could not be addressed or resolved by amending the technical proposal constitute the potential negative effects of the proposed new river typology, new river water bodies network and assessment groups.

With respect to the methods of stakeholder consultation, as it was found from the literature review, the important point for initiating a consultation process is to establish a space where stakeholders meet, discuss and deliberate, without giving too much emphasis on the name of this “space”. Following from this, the particular **methods** applied were selected to create such a space in a format similar to group interviews, focus groups and consultative panels in the sense of Finch and Lewis (2003). The consultation sessions were organized taking into account issues that had been identified as potentially problematic in the literature review. The main points in this respect are described in the following:

The technical nature of the subject of the consultation warranted that each session had to start with a thorough introduction to the subject to establish a common baseline for all participants (cf. Hernández-Mora and Ballester, 2011, Zikos, 2010), explaining the problems that are to be addressed and alleviated by the proposed changes; after this introductory part, a detailed presentation of the technical proposal followed. The latter was undertaken using, as much as possible, simple language and avoiding technical jargon (cf. Russell, 2010, De Stefano, 2010, Smith et al., 2013). Participants could ask questions at any time; this approach allowed clarifying unclear issues immediately so that participants were able to continue following the presentation at all times without doubts and uncertainty whether their understanding of the proposal is correct. After the presentation of the problems and the “technical proposal”, the stakeholders were asked to deliberate in informal discussions-as-interviews, during which I extracted the views of the participants. In this group context participants influenced and were influenced by others - just as they are in real life (Krueger and Casey, 2000, p.11, in Finch and Lewis, 2003). These interactions between stakeholders, the opportunity to hear different or opposing views, to listen and reflect on what is said and to consider their own standpoint further, led to additional material being triggered and data being generated (Finch and Lewis, 2003). In addition, the possibility for sending responses or communicating with me at all times was given to the participants. In general, the chosen approach is a rather common one and a similar procedure was used e.g. for the WFD consultation process in the Czech Republic, where presentations were followed by open discussions (Slavíková and Jílková, 2011).

During the consultation, I pointed out the normative and technical constraints of compliance with the Directive, which represented the limits of changing the proposal, to the stakeholders and this indicated to what extent they could influence the final outcome of the discussed topics. This ensured that the stakeholders had clarity about their role in the process and knew what impact they could make (Mostert et al., 2007, Pares, 2011).

The potentially limited interest of stakeholders and in particular their limited time had been identified in the literature review as a point of concern (cf. Pares, 2011, Benson et al., 2014, van der Heijden et al., 2013); indeed Cyprus stakeholders, Government Departments etc. are usually very limited in time and, due to the economic crisis, suffer from staff shortages. As a consequence, the stakeholder consultation process had to be organized in a way that makes limited demands on the stakeholders (Mostert et al., 2007) with respect to time and staff. In order to accomplish this, I decided to start with sessions of stakeholder groups who are supposed to be most concerned by the subject of the project, and thus also most knowledgeable. Based on the outcome of the initial sessions I would then proceed with stakeholders who are "further away" from the subject, evaluate to what extent they can contribute and decide which other stakeholders to consult as the consultations go ahead, or not to consult any further stakeholders.

This approach attempts to respond to the problem of consulting technical issues with stakeholders as it was described by Howarth (2009, p.406); he had found that "as the issues become more specific and specialised, the pool of potential participants becomes progressively smaller, though the importance of decisions does not diminish, where, as often, 'the devil is in the detail'". The selected approach is also in line with van der Heijden and ten Heuvelhof (2012, p.12) who called for a process that is "tuned down to those who are, at that point in time, most affected". The reference to "at that point in time" is of importance in the DProf context, because it is well possible that some stakeholders may not feel affected at this stage, and would thus be unwilling to participate, while they would realize to be affected after some time, e.g. once the Programme of Measures according to the WFD RBMP will be in place.

In that sense, the selected approach would avoid consulting with stakeholders who cannot contribute, and this would also avoid unnecessarily wasting stakeholder's time. It is recognized that such an approach bears the risk of excluding potentially interested stakeholders due to wrong estimation of their knowledge and interest in the subject; still, I am convinced that my experience form working with most of the stakeholders over the last years allowed me to decide with a minimal risk of misjudgement.

It was also considered wise to combine consultation sessions for the DProf project with "official" WFD events where major stakeholders would be attending. This had the advantage that the consultation could be held within office hours and also of reducing the events where stakeholders would be called upon, thus helping to save time, both of the stakeholders and of myself, within the tight time frame of the DProf project. Because the main stakeholders are

Governmental organizations and organizations who work governmental office hours, it would have been impossible to hold consultation sessions for the DProf project only, outside of office hours, and participation would probably have been greatly reduced. On the other hand, it was not possible to hold sessions exclusively for the DProf project within office hours.

Following the above approach, the stakeholders at the consultation sessions already knew each other, i.e. they represented the networks in which “people might normally discuss (or evade) the sorts of issues likely to be raised in the research session”; such networks were considered by Kitzinger and Barbour (1999, p.8f) “one of the most important contexts in which ideas are formed and decisions made”, thus indicating that the proposed groups are suitable for the purpose of the DProf project.

The following stakeholders had been identified:

1. The Water Development Department is the main stakeholder and most response was expected from this Department
2. Other Government Authorities that are affected by the changes proposed by the project are:
    a. Department of the Environment
    b. Department of Agriculture
    c. Geological Survey Department
    d. Department of Fisheries and Marine Research
    e. Department of Forests
3. Environmental NGOs
4. Agricultural groups
5. Local Authorities (Communities, Municipalities)

The order of the above list corresponds to a decreasing degree of involvement and knowledge in the WFD’s implementation in Cyprus.

The above groups were planned to be called upon for consultation as described further above, i.e. starting with the most involved stakeholders and proceeding to stakeholders who are “further away” from the research subject and developing the consultation process on the basis of the stakeholder’s response. However, because the consultation sessions showed that not even the Government Authorities did contribute, except for limited input from the Department of the Environment, the stakeholders under points 3-5 were not called upon except for the last consultation, i.e. the public stakeholder event as described in chapter 3.2.2.3 below.

For the **data capture and analysis**, audio taping was applied, after agreement by the persons taking part; as this is common practice in most meetings to facilitate the writing of minutes, consent was always given. I had planned to take written notes during the sessions but in the end I never had the time to do so; in any case, I wrote analytical memos (Saldana, 2009) immediately after each session as a means of documenting my impressions and describing the situation, as had been suggested by Goulding (1999). As far as analysis is concerned, I deemed it not necessary to transcribe the entire session of all consultation events. Selective picking out of relevant passages (Robson, 2002) was considered sufficient to capture the points of concern of the stakeholders about the proposed change and to produce the transcript. This approach is chosen based on the supposition that the concerns articulated by the stakeholders are assumed to be rather concrete issues, which do neither affect them personally nor emotionally in a direct way. Consequently, I do not need to discover the sought answers from subtle meanings of the participants' articulations. Nevertheless, the statement of Robson (2002, p.288) that "groups are notoriously difficult to get good recordings from" proved right even for the above procedure of picking out relevant passages, as I found it very difficult, in a number of occasions, to identify what was said e.g. in instances when several participants were talking at the same time; as a matter of fact, there were few cases where it was impossible to identify what was exactly said by whom.

The methodology for the **coding and analysis of the transcripts** is described below.

At first a "start list" of codes in the sense of Miles and Huberman (1994, p.58), who referred to creating start lists as their preferred method of creating codes, was assembled. The list was based on the research questions, the conceptual framework of the project, the targeted structuring of the data (Punch, 2009) and on topics that had emerged as potentially important during the project e.g. from the literature review; in that sense, each component of the technical part of the DProf (river network review, river typology, WB delineation, WB grouping – assessment groups) was also given a code to identify corresponding text segments, as each session was given a "session code". This start list of codes was created following the concept of "end-use strategizing" (Impact, n.d.), i.e. it was built in such a way as to ensure categorizing the data in a way which will produce "the right kinds of data slices or bags" (Mason, 2002, p.159) that will subsequently enable the targeted extraction of the required information for answering the research questions at hand.

Because the consultation sessions were held in groups, the transcripts were indexed with speaker codes to facilitate the information of each participant to be retained and to preserve the interactions between individual members in the codes, in the sense of "participant based group analysis" (Ritchie and Lewis, 2003, p.258ff). Initially it was not clear whether this effort would yield any added value for the analysis but I considered it worth the effort, much more so because I had identified different views between the participants, even between participants of the same organization, during the first consultation sessions; this was thus a methodological decision that was influenced by findings from the ongoing project itself.

While transcribing the consultation sessions, the approach suggested by Ezzy (2002, pp. 67–74, in Saldana, 2009) to "initially code as you transcribe interview data" was followed and the codes that had emerged from that process were also added to the "start list".

From the above it is clear that two or more different codes may be applied to a single qualitative datum or that two or more codes, applied to sequential units of qualitative data, may occur in an overlapping fashion, thus resembling coding patterns that were termed simultaneous coding (Saldana, 2009) and multiple coding (Miles and Huberman, 1994).

The coding itself was undertaken as suggested in very similar ways in a number of textbooks: Codes were assigned to "monothematic chunks of sentences" (Miles and Huberman, 1994, p.64) that "signal the occurrence of specific information" (Gläser and Laudel, 2013, para.43) after "reading each phrase, sentence and paragraph in fine detail and deciding 'what is this about?'" (Ritchie and Lewis, 2003, p.224).

The software AQUAD7 (Huber, 2015) was used for coding and for extracting of information. The specific software was selected because it includes features that "enable the analysis of transcriptions of group discussions in total as well as group member by group member" (Huber and Gürtler, 2013, p.75) thus rendering it advantageous for the analysis of the group interactions of the stakeholder consultation sessions.

As the coding went ahead, codes that emerged were added to the code list. These codes, following the coding methods typology of Saldana (2009), fell mostly into the following categories:

- Descriptive coding, to summarize the basic topic of a passage of qualitative data
- Process coding, to index actions/interactions/emotions taken in response to situations, often with the purpose of reaching a goal; for process coding gerunds ("-ing") words were used. These process codes in fact describe interactions between participants like affirmations, disagreements, conflicts according to the suggestion of Ritchie and Lewis (2003).

Lastly, interesting participant quotes were also specifically labeled for their easy subsequent retrieval and potential inclusion in the project report (Creswell, 2007).

After completion of the initial coding of all transcripts, the master code list was analyzed and a number of codes were joined as they referred to the same theme. The final master code list is shown in Appendix 5.

The codes themselves were used for a brief quantitative analysis that provided an overview about the most frequent codes and subsequently, they were used to selectively query all text segments related to research questions, DProf components etc. and the selected raw data was interpreted and analyzed (Gläser and Laudel, 2013, para.55). Some if not most of the main themes had already made their way into my memos, because the discussions with participants were usually rather straight to the point and the topics were few and repeated themselves to some extent. While the memos were interpreted and analyzed in parallel with the selected raw data, it was the latter that contained the crucial information and allowed to precisely extract and describe the themes. By means of this analysis, the identification and definition of the main themes were achieved, while few common themes that cut across the data were also revealed.

The stakeholder consultations were carried out in two loops with a total of five sessions, as described below.

3.2.1 Stakeholder consultation – action research loop 1

The fact that the project was embedded in the real-time implementation process of the WFD and in particular in the preparation of the second RBMP, forced me to adjust the initially planned AR programme. The critical constraint was that the outcome of the DProf project had to be delivered on time to consultants who would then carry out the classification of water status and the review of Art. 5 of the WFD with respect to the review of pressures acting on water systems; these studies had to be based on the new river water body network that resulted from the DProf project. Because the preparation of the technical proposal and especially the review of the river network and the elaboration of the new river typology including its application to the new river network took longer than planned, it was not possible to present the complete "technical solution" in the 1st action research cycle to the stakeholders. Still, the stakeholder consultation had to start eventually and I decided to conduct the 1st AR cycle based on the proposal for the new river network and the new river types as applied to the new river network only, while the 2nd AR cycle would be based on the complete "technical solution" as originally planned. My decision was influenced by the fact that early involvement of the stakeholders is considered important in consultation processes (Reed, 2008, De Stefano, 2010); on the other hand the technical proposal had to be mature enough for presentation and discussion with the stakeholders. Consequently, the time of the first sessions had to be decided based on the progress of the technical work, by finding a balance between technical maturity of the proposal and limiting the delay of starting the consultation process.

Finally, two sessions were held for the first action research loop.

3.2.1.1 First stakeholder consultation session

For the first consultation, participants from the Water Development Department, i.e. from the most involved stakeholder, were invited and participated. The session took place in the main meeting room at the headquarters of the Water Development Department on 8th November 2013 and the participants are given in Appendix 6.

All participants are involved in the implementation of the WFD and the group included the "core group" of the Directive's implementation at WDD. I had invited the specific colleagues for this very reason because one objective of this first consultation session was to gauge the degree to which highly involved stakeholders can contribute to the technical topics of the project. In addition, the participants come from several divisions within the WDD, include both Heads of Divisions and subordinated scientific personnel, thus representing a good mix of technical knowledge and interests within the Department. While it is acknowledged that in a group context at the workplace, substantial differences in status between group members should be avoided (Finch and Lewis, 2003), it was not possible to hold separate sessions due to time constraints. In addition, I considered that the matter does not pose an issue in the DProf case because decisions for official critique or opposition have to be approved by Heads of Divisions and, therefore, divergent views of subordinate staff would not cause "potential negative effects" in the sense of the Objective 4 (cf. chapter 1.2) of the DProf project.

The session was audio-recorded except for the very beginning of the session (approx. 10 minutes) that is missing from the recording due to technical problems. I wrote a memo of the session immediately after it, recording the main points raised and discussed as well as reflections about my own acting and points for improvement in light of the next consultation sessions. While it was initially planned to transcribe the session by just selectively picking out relevant passages, it was finally fully transcribed because questions and discussions were very much interwoven with my presentation of the proposal. For the transcription process itself, the sequence described by Gibbs (2012) was turned upside-down: First, the session was transcribed word-by-word, frequently interrupting the recording to catch up with the transcript; this initial phase was followed by listening intensely through the material ("immersion") in long uninterrupted pieces while reading the transcript in parallel, a process that allowed for the identification and noting down of the themes and facilitated finalizing the transcript in parallel. While transcribing, language was translated on-the-fly from Greek to

English. The quality of the audio recording was poor thus making transcribing very difficult; the use of a better recorder was envisaged for the next session.

I considered the first consultation meeting too long, and thought that I should present less technical details in the next sessions. In addition, I felt that in some moments the audience could not fully follow the technical details; recognizing this was especially important because the session was quite long with much time spent at explaining the very technical details. This presented a dilemma because on the one hand, there was not enough time for explanation and for full deliberation and contribution of the participants, and on the other hand the session was already too long. Upon reflection and weighing possible options, I decided that it is not feasible to provide even more technical detail to allow for full comprehension and more contribution by the participants of the next stakeholder consultations. Instead, I would focus on explaining the problem and on presenting the solution, including changes to the old water body network and river typology, and I would only briefly present the technical approach and technical details.

3.2.1.2 Second stakeholder consultation session

For the second stakeholder consultation, all Governmental Departments that are significantly involved in the WFD's implementation were invited. The presence of all significantly involved Departments would allow for coordination between different departments in the sense of Hernández-Mora and Ballester (2011). The session took place in the main meeting room at the headquarters of the Water Development Department on 22nd November 2013 and the participants are presented in Appendix 6.

Based on the lessons learnt from the first consultation session, I had shortened my introductory presentation and had focused it on the problem to be addressed and the solution proposed by the project. This changed approach proved advantageous and the session was not conceived as too long, while all participants gave the impression of remaining interested until the session's end.

3.2.2 Stakeholder consultation – action research loop 2

After the 1st action research loop, the technical proposal was finalized by completing the pending parts of the proposal and by taking into account the issues that had emerged from the first loop. As soon as the technical proposal was complete, the stakeholder consultations of the second AR loop were organized.

Three sessions, numbered as stakeholder consultation sessions three, four and five, were held for the second loop and they are described below.

3.2.2.1 Third stakeholder consultation session

For the third stakeholder consultation, participants from the Water Development Department, i.e. from the most involved stakeholder, were invited, corresponding to what had been done in the 1st loop. In addition, staff of a WDD contractor who had been awarded a contract to carry out the status classification of inland waters, that would subsequently be used as a basis for the second RBMP, was also invited because the company had become quite involved in the new river typology, new river water bodies network and assessment groups because they had to work with it in practice in the course of their contract and thus I deemed the company's staff very knowledgeable in the DProf project's topics. The session took place in the main meeting room at the headquarters of the WDD on March 7, 2014, and the participants are shown in Appendix 6.

I started the session with a brief repetition of what had been presented in November 2013, during the 1st action research loop, and then continued to present the final technical proposal. Even though the session was quite long again (1 hour and 45 minutes), the participants did not show any signs of getting bored or tired.

The session was audio taped and only the passages of questions, answers and discussions were transcribed. The transcription process was the same as in the previous sessions. I also wrote a memo of the session immediately after the session, collecting my immediate reflections and a summary of the main themes that emerged and were discussed.

3.2.2.2 Fourth stakeholder consultation session

After the positive feedback received in the 3rd consultation session, which did not reveal any significant objections to the technical proposal, I felt that the latter had *de facto* been accepted. Based on this impression and taking into account the difficulty in explaining to the stakeholders the effect of the proposed changes in the previous sessions, in particular in the 2nd session when the Government Departments did not deliberate at all, I deemed it beneficial to combine the fourth stakeholder consultation session with the presentation of the river water status of the period 2009-2013, that had been elaborated by consultants based on the new river typology, water body network and assessment groups proposed by the DProf project and would serve as a basis for the second RBMP. In so doing, the participants would have the chance to see the DProf proposal implemented for the determination of river water status, which is one of its main purposes.

I was aware that the above decision would have both negative and positive effects with respect to the purpose of the DProf project. In rough terms, the trade-off was between, on the one hand, the distraction of the participants from the DProf project's topics by the other topics presented in relation to the rivers' water status, and on the other hand the opportunity to show to the participants the practical implementation of the new river typology, water body network and assessment groups proposed by the DProf project. There was a risk that topics unrelated to the DProf would dominate in discussions and I was aware that in such a case, the dynamic of the group discussion would make it very difficult to return to concerns with respect to the DProf's proposals; such concerns may well exist but be less important to the participants-stakeholders than other unrelated topics. Still, I judged the opportunity to present to the stakeholders a real implementation of the proposed changes, instead of having to resort to explaining potential impact and effects in a "virtual" way, to be unique and to outweigh concerns of distraction of the discussion towards issues unrelated to the DProf project. I estimated the chance to retrieve valuable feedback based on the presentation of the easier graspable impacts and effects to be greater than in a consultation session dedicated only to the DProf project during which these impacts and effects could only be explained in a "virtual" way.

At the time when the fourth session was held, i.e. after the *de facto* acceptance of the technical proposal in the 3rd consultation session, the technical proposal had already been used by WDD consultants to assess the water status for each water body, i.e. for each water body as it had been delineated within the DProf project. Therefore, it was clear that the fourth consultation session could not provide any feedback that would be incorporated into the technical proposal; however, the session was expected to yield important input as far as the stakeholder's anticipation of the benefits and negative effects of the new river typology, water body network and assessment grouping scheme is concerned. In other words, it was expected to provide an excellent opportunity to gauge potential future critique and reactions against the implementation of the aforementioned changes, which correspond directly to Objective 4 (cf. chapter 1.2) of the DProf project.

The 4th consultation session took place on March 28th 2014 and all involved and affected Governmental Departments were present. At this event, I gave an oral introduction explaining and summarizing the work done with respect to the new river typology, water body network and water body grouping (assessment groups scheme), while the presentation of monitoring results and water status was given by the consultant who had been awarded the contract for the assessment water status, in preparation of the third river basin management plan. The participants of the event are presented in Appendix 6.

The session was audio taped and only the passages of questions, answers and discussions related to the DProf project were transcribed. Due to technical problems approximately the first 15 minutes of the session, which had a total length of about 3 ½ hours, were not recorded; the missing part includes my introductory talk but luckily no discussions or questions relevant for the DProf project. Therefore, the recording is considered to include all relevant material. The transcription was done as in the previous sessions.

In the discussions themselves, a small number of people dominated throughout the session and brought up the same issues time and again. On the other hand, other participants who had contrary views expressed them quietly and not repeatedly. In that respect, the audio recording helped to collect all views including those that were expressed calmly and without multiple repetitions.

3.2.2.3 Fifth stakeholder consultation session

This session took place in the framework of the official public consultation process for the second RBMP and specifically in the first consultation stage that is dedicated to significant water management issues. It had been explicitly requested by the European Commission (COMM), in the course of the bilateral process of evaluating the first RBMP, that Cyprus puts the changes proposed to the river water body network to public consultation (European Commission, 2013a); such changes had already been proposed in the first Cyprus RBMP but referred merely to removing small ephemeral rivers from the network. In response to this specific request from COMM and because the topic was addressed in the DProf project, I gave a special presentation on the issue of streams that were water bodies in the first RBMP but that were removed from the water body network for the second RBMP, based on the proposal of the DProf project. My presentation was one of four that were held during the event, which took place on November 1st, 2014 and the participants are presented in Appendix 6.

For this presentation, taking into account the experiences from the previous consultation sessions, I included slides that explained the relations and mutual repercussions of river typology - water bodies – monitoring - classification and a "layman" summary was also part of the presentation. This approach was chosen to provide the present stakeholders with the base knowledge to understand the potential impact of changes to water body network, typology etc. In addition, the presentation was organized in such a way as to address and put to consultation exactly the questions that had been put forward by COMM, which were also relevant questions for the DProf project with respect to the positive and negative effects of the changes to the water body network. Nevertheless, in the presentation I addressed the new river typology too, and mentioned that in my view, the typology was a more important problem to be solved than the issue of small ephemeral rivers.

Because the event was part of the official public consultation process for the second Cyprus RBMP, a wide range of stakeholders were present, including also (at least) two environmental organizations (Friends of Akamas, Union of Environmental Organizations), two large agricultural organizations, the Union of Communities and also representatives from several Municipalities.

This last stakeholder consultation represents the conclusion of the two loops of stakeholder consultations. The results of the analysis of the five consultation sessions are presented in chapter 4.2.

3.3 Interactions of the DProf project with other activities

The fact that the DProf project is fully embedded in the implementation process of the WFD in Cyprus means that I am continuously in contact with a number of issues related to the project's contents. It is, therefore, unavoidable that I am influenced by the project-relevant information I was confronted with during the course of the project, which coincided with the preparations for the elaboration of the second RBMP. I accepted these information sources as an opportunity to gather more opinions and views on anticipated benefits and potential negative effects of the proposed new river typology, new river water bodies' network and assessment groups. The most substantial of these additional information sources are listed below:

- I prepared the Terms of Reference and subsequently coordinated a service contract for the "Review and update of article 5 of Directive 2000/60/EC (water reservoirs) & classification of water status (rivers, natural lakes and water reservoirs), that will establish baseline information and data for the second Cyprus river basin management plan". I contributed chapters 5.1.1 and 5.1.3 to the final report of the contract.
- I was deeply involved in the compilation of the Terms of Reference for a service contract for the "Update of Article 5 of the Water Framework Directive (2000/60/EC) for the review of pressures and impacts of human activity on the status of surface water and groundwater, and Article 14(1)(b) for the review of significant water management issues in Cyprus". Subsequently I contributed extensively to the provision of guidelines to the contractor, the checking of the results of the contract and I also contributed Appendix B to the final report of the contract, which is an application of the methodology for the elaboration of the assessment groups scheme that has been developed in the present study (cf. chapter 3.1.7) using real pollution loads.
- I was deeply involved in the compilation of the Terms of Reference for a service contract for the elaboration of the second Cyprus RBMP, I was a member of the respective tender evaluation committee, I am a member of the steering committee of the contract and I contribute extensively to coordination of the contract.

- I had communications with colleagues in the responsible authorities for WFD implementation in Spain and in Malta who were interested in the approaches I had adopted in the present study. Spanish colleagues contacted me and asked for information about the Cyprus' water bodies' grouping scheme, and I provided the methodology for the elaboration of the assessment groups scheme that has been developed in the present study (cf. chapter 3.1.7). I had extensive communication with the Maltese colleague about the issue of water body delineation for small temporary streams and in particular about temporary river typologies for the implementation of the WFD. Permission for inclusion of the communications in the DProf report was granted both from Spain and Malta, and the correspondence is included in Appendix 7.
- I was in charge of revising the WFD river monitoring scheme by transferring it onto the water body network, the river typology and the assessment groups scheme proposed by this study.

3.4 Ethical considerations

I updated the assessment of the DProf project for potential ethical issues, which I had undertaken in the Project Planning module (DPS4561), in the early phases of the project itself. This assessment led to, despite the rather technical character of the project that deals more with the environment and natural processes than with people, to the identification of some potential ethical issues, which are mentioned below.

Economic implications for the Cyprus Government was one identified issue. This could have happened because the changes to be proposed by the project may have led to e.g. an increase of required monitoring efforts for the status assessment of Cyprus rivers, as more river types might have to be monitored. I was thus aware of the issue and took it into consideration once the outcome of the project allowed re-evaluating whether the issue needs to be addressed.

My role within my organization poses another ethical issue, due to the dual roles (Middlesex University, 2011) I play. In my first role, as practitioner-researcher, I am elaborating recommendations for change within the Water Development Department, having in mind the advancement of the Department and, in a wider sense, of Cyprus' water policy as a whole. My second role is that of a hydrologist in the Division of Hydrometry of the WDD, which is my current job position. Theoretically there is a chance that I would favour recommendations for decisions and solutions that would be of advantage to my Division, by e.g. justifying additional staff or by extending its role and importance within the WDD, even if they might not be the best choices for the Department, stakeholders or for the country's water policy overall. Even if this would not be true and my recommendations turn out to be entirely objective and based on justified facts, colleagues might still judge that my proposals are biased towards favouring my immediate workplace, the Division of Hydrometry, just because it seems "common practice" that people promote their immediate workplace first before thinking on the progress of the whole organization, or the country.

A scenario like the above needed to be avoided and the strategy to pre-empt its occurrence was to pay special attention to emphasize and clearly point out the scientific unbiased approach and how proposals and decisions were based only on the outcome of this scientific approach and "hard data" as input.

With respect to the analysis and presentation of the stakeholder consultation's results, the handling of personal information of stakeholders posed another ethical issue. Of course names were not exposed, and the chosen approach was to use each stakeholder's position name and a numbering in case there was more than one stakeholder holding the same position. I am aware that a small ethical issue remains in cases where only one stakeholder holds a certain position, as in these cases people that participated in the consultations would be able to identify the specific person. However, I considered it crucial to retain the position names because they would allow identifying critical clues to the motives etc. behind each deliberation, and therefore this strategy was adopted.

The theoretical possibility that higher management of the WDD might try to exercise control over what is reported or adopted was also identified as a potential ethical issue. Such a possibility exists because, in the sense indicated in the DPS 4561 handbook (Middlesex University, 2011), the position of the WDD as main stakeholder could generate conditions that promote the internal nature of the project. The strategy to avoid such a development beforehand is the involvement of all relevant stakeholders and the open discussion of all issues at hand, as it was anyway planned for the stakeholder consultation.

As far as environmental ethics are concerned, I found that the DProf project does not create critical issues. On the contrary, taking into account that the project set out to establish a new scheme that would be better adapted to the actual environmental reality, it became clear that positive effects for the environment were to be expected.

Chapter 4. Findings, outcome and discussion

This chapter includes the findings of the entire project activity and presents them with respect to the components of the project (cf. Chapter 3) and making reference to the project's objectives (cf. chapter 1.2) where appropriate. For each sub-component of the "technical part" of this study, the results and discussion, where appropriate, will be presented in the same chapter (4.1.1-4.1.6); for the stakeholder consultation, however, the results will be presented in chapters 4.2.1-4.2.5 and the discussion is presented separately in chapter 4.2.6.

4.1 Development of the new spatial basis for river monitoring and management - technical part of the DProf project

4.1.1 Review of the river network

The resulting WFD stream network includes 60 streams; a map of the stream network is presented in Figure 11 while the streams are given in tabular form in Appendix 8. The total catchment area of these streams is 6529.2km^2 corresponding to 70.6% of the total land area of the island of Cyprus. Of this catchment area, 1555.1km^2 or 24%, which correspond mainly to the Serrakhis, Pedhiaios and Yialias catchments, are in those areas of the Republic of Cyprus in which the Government of the Republic of Cyprus does not exercise effective control and where the application of the acquis is suspended.

The resulting stream network differs from the one derived by WL | Delft Hydraulics et al. (2004) and used for the first RBMP and management period, as follows:

- Six rivers with catchment areas between 27.9 and 12.5km^2 were added to the stream network. The total catchment area of the six added streams is 104.9km^2 and their total stream length is 40.9km. The streams are presented in Appendix 9.
- 25 streams of the water body network of 2004 were removed, corresponding to a total catchment area of 83km^2 (Appendix 10). One of the 25 streams had been designated HMWB in the first RBMP but was found to have no channel developed in this study; the remaining 24 streams correspond to a total catchment area of 80.9km^2 and stream length of 84.8km. The mean catchment area of the remaining 24 streams is 3.4km^2. Eleven of these streams are located in the Paphos region, 7 are located in the Polis Chrysochou area and 6 in the Kokkinokhoria area; based on local knowledge, the large majority of these rivers has an episodic flow regime.
- The total catchment area of the proposed streams is 6529.2km^2, i.e. slightly larger than the total catchment area of the stream network of 2004 (6507.1km^2).

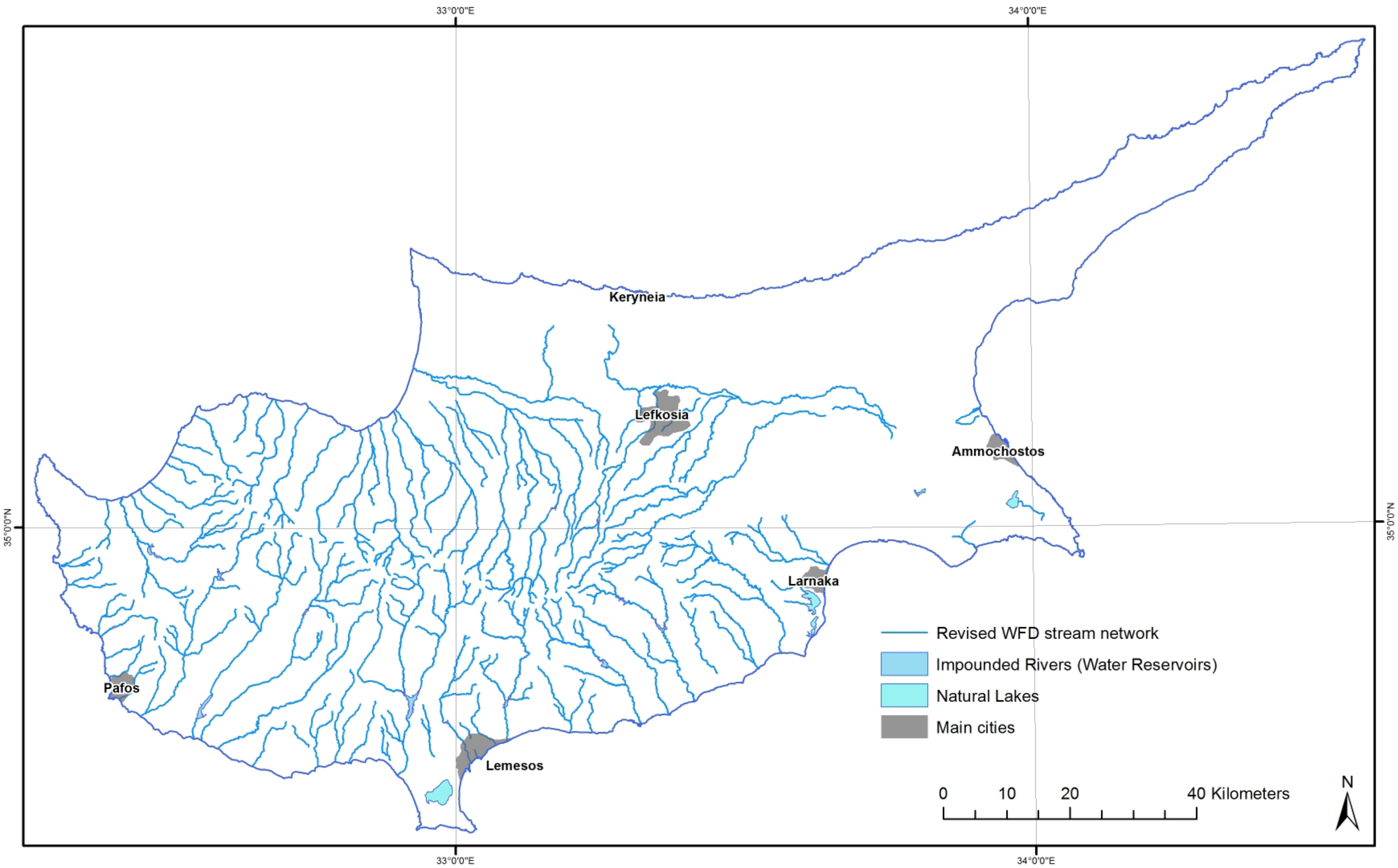
- The total length of the stream network decreased slightly from 2637.5km in 2004 to 2623.1km in the present study. The length of the streams in the area in which the Government of the Republic of Cyprus does not exercise effective control doubled from 102.3km in 2004 to 203.9km in the revised stream network; this is due to the approach to include in the stream network the main trunks of the large streams (Serrakhis, Pediaios, Yialias) up to their mouth.

With respect to the future protection and management of the streams that are, in comparison to the stream network of the first RBMP, being removed from the network, a solution following WFD CIS Guidance Document no. 2 (European Commission, 2003a) is proposed. This guidance document suggests three potential approaches of dealing with small surface water elements. The first two approaches propose to delineate the small surface water element, either as part of a neighbouring water body or in a group of small surface water elements of same type and pressure; both approaches are not feasible for these small water bodies because, due to their episodic flow regime, no suitable methods are available for assessment of their status. Therefore, the third option is considered the most feasible and is proposed to be adopted: these small streams will be protected and managed in line with the objectives of other, neighbouring, water bodies and/or in line with the objectives of the protected areas in which they are located (European Commission, 2003a, p.13).

In addition, all watercourses that are registered on LRO cadastral maps are protected by the Integrated Water Management Law 79(I)/2010; to this end it was checked and found that all 25 streams proposed to be removed by this study are registered watercourses on LRO cadastral maps.

For a comparison of the approach in other E.U. Member States with respect to the review of the river network for the second RBMP, only one reference was found; this scarcity of information is probably due to the fact that the Member States were preparing their RBMPs at the time of writing this report and had not yet published relevant documents. Nevertheless, a consultation document for the Anglian River Basin District in the U.K. was located (Environment Agency, 2014) that indicated an approach very similar to what was undertaken in the DProf project: As main changes, the Environment Agency (2014) mentions the removal of small water bodies around the coastal fringes, just as it was done in this study with the 25 streams that were removed from the stream network, and that all changes are in line with European guidance on minimum sizes of water bodies, which corresponds to the drainage area threshold of $10km^2$ that was applied in the DProf project too.

Figure 11: Revised WFD stream network



4.1.2 Elaboration of the new river typology

The findings below correspond to the DProf project's Objective 1: To elaborate a new typology for Cyprus rivers, based on their hydrological regime.

The application of the TSR-Tool yielded the definition of the four river types for Cyprus shown in Table 19.

Table 19: Proposed river types for Cyprus

Type	Type name
P	Perennial mountain streams
I	Intermittent streams
Ih	Harsh intermittent streams
E	Ephemeral / episodic streams

The average catchment characteristics and the average hydrological characteristics of the four river types were determined from the catchments of the flow gauging stations that had been used in the analysis and are presented in Table 20 and Table 21 respectively.

The presentation of catchment and hydrological characteristics in Table 20 and Table 21 follows the continuum concept described by Uys and O'Keeffe (1997) that attempts to discriminate river types according to the core characteristics ("inner limits") that define them, in contrast to classifications that distinguish categories based on boundaries ("outer limits"); the TSR plot in Figure 6 would be an example of the latter. According to the continuum concept, river regimes are defined by "inner limits" e.g. average values and these are placed along a continuum. Transitional river regimes are placed in the "fuzzy zone" between the "inner limits", i.e. where the blurred boundaries between categories of the classifications ("outer limits") are located.

Standardized median monthly flows from stations corresponding to the four TSR types are shown in Figure 12, mimicking similar graphs presented by Bejarano et al. (2010) for rivers in the Ebro basin in Spain. Figure 13 mimics similar graphs presented by Belmar et al. (2011) for rivers in the Segura basin in Spain and shows means and percentiles of standardized median monthly flows from the same data set as in Figure 12. For these graphs, the stream flow time series from the 29 flow gauging stations for the period 1985/86-2004/05, which were utilized for the stream typology elaboration (cf. chapter 3.1.3), were used. For each station the median monthly flows were standardized by the mean of all monthly medians. The median was preferred over the mean because mean monthly flows are considered unsuitable for depicting the highly skewed flow time series of Cyprus rivers.

Each of the graphs in Figure 12 and in Figure 13 shows the within-type variability, i.e. the variability between the stations used, while the graphs between each other illustrate the differences between the stream types. The graphs in Figure 12 and in Figure 13 illustrate the strong seasonality of flow typical to Mediterranean regions, that is more predictable than in many other areas where temporary streams occur (Boulton, 2014). According to the “global river regime classification” of Haines et al. (1988), Cyprus rivers would fall in group 13 “Extreme Winter” together with the southwestern Iberian peninsula, coastal California, a part of South Africa and the Southern Australian coast, and the group is described to have very strong winter and early spring flows which then dwindle to a very low level over summer; this characterization fits very well the Cyprus river types determined in this study, and the flow regime pattern of group 13 “Extreme Winter” presented by Haines et al. (1988) resembles very much the graphs shown in Figure 12 and in Figure 13, especially for types P, I and Ih.

Even ephemeral/episodic streams exhibit some seasonality, but this is largely limited to the fact that flow occurs between December and April while the variability within the type is huge and erratic as is clearly shown on Figure 12. Still, even this weak seasonality demonstrates that in wet years, these rivers may exhibit flow that lasts for several weeks to few months, at least in the larger rivers of that type.

Figure 12 and Figure 13 clearly show the shorter flow period of the Ih type compared to the I type: In Ih-type streams, June, October and November are dry, while these months have some flow in streams of the I-type; the small flow in these months is crucial for the ecosystem. Another interesting aspect is the increasing within-group variability with decreasing flow period, i.e. from perennial to intermittent, harsh intermittent and ephemeral streams, e.g. the variability in Ih streams is more than double than in I type streams for the months December, January and March.

The Temporary Stream Regime Plot (TSR plot) created with the Cyprus stream flow records has a striking similarity with the corresponding plots from Evrotas river in Greece from Cazemier et al. (2011). This firstly confirms their modeled results with stream flow records and secondly it shows that the specific alignment of flow regimes (i.e. pairs of the Mf and Sd6 metrics) on the TSR plot seems to be valid for natural, or near-natural, flow regimes over wider Mediterranean areas and not only the one, even though large, catchment that had been investigated by Cazemier et al. (2011); the plot may well proof to be valid as a general Mediterranean relationship, once data from more areas will become available. In that respect it is also worth noting that the Temporary Stream Regime Plot in the original paper from Gallart et al. (2012), in which they had proposed the TSR plot method, did not exhibit this alignment along an asymptotic curve.

For further comparison of the Cyprus stream types with other Mediterranean countries, the Segura basin in southeast Spain is suitable; this region experiences hot semi-arid climate (Köppen-Geiger class BSh) over a significant part of its area, while this climate is also typical in the central and eastern Measoria plain in Cyprus. The Segura basin is known as one of the most arid zones of the Mediterranean area and precipitation varies from >1000mm in the mountains to less than 350mm in the lowlands (Belmar et al., 2011) which are also conditions comparable to Cyprus. A comparison with the work of Belmar et al. (2011) shows that the Cyprus graphs exhibit greater seasonality, in all comparable types, and for this reason the numerical range in the means of the standardized monthly flows is much larger for the Cyprus data. In the graphs of Belmar et al. (2011) of rivers in the Segura basin, even their intermittent stream type exhibits a very small seasonality only. For this interpretation one has to consider that the Cyprus types, by applying the TSR method, were not distinguished by their intra-annual variability, i.e. this was not a criterion for the distinction of types, while it may have been in the Spanish study; Belmar et al. (2011) may well have grouped types of similar intra-annual variability thus creating groups with reduced within-group variability. It must also be taken into account that Belmar et al. (2011) had used modeled flows, while the Cyprus types are based on stream flow records.

In the Catalan River Basin District in Spain, only one of the ten types determined by Munné nd Prat (2004) refers to temporary rivers and this type includes “temporary and ephemeral streams” with intermittent flow regime, defined as having a dry period of at least four months; this allows the conclusion that rivers with a dry period up to four months are included in some of the other nine types. However, no distinction in different types of temporary rivers was made by Munné and Prat (2004). On the other hand, in the abovementioned Segura basin which has a considerably drier climate (Köppen-Geiger classes BSh and BSk) than the Catalan region (Köppen-Geiger class Csa), Belmar et al. (2011) had identified a total of eight stream types, of which two are temporary rivers: one with intermittent and one with ephemeral flow regime. These two types account for more than 60% of the total drainage area and are thus the predominant classes in the Segura Basin. A comparison of the Spanish examples with the present study shows that only in the Segura region, which has a comparably dry climate as Cyprus, temporary river types were further differentiated.

The Portuguese national river typology (Aguiar et al., 2008, in Dodkins et al., 2012) does not distinguish perennial and temporary rivers but uses river size and geographical location as parameters, thus being quite different from the typology proposed in this study. Dodkins et al.

(2012), on the other hand, propose a different typology for Portuguese rivers that distinguishes temporary from perennial rivers, but it does not further differentiate the temporary rivers. The conclusion from the above is that both examined Portuguese typologies give much less attention to the gradient of flow permanence than the present study. This may be due to Portugal having a less hot and dry climate than Cyprus: Only in its Southern part does Portugal experience the hot Mediterranean climate that is typical for parts of Cyprus (Köppen-Geiger class Csa), and Portugal does not experience at all the hot semi-arid climate (Köppen-Geiger class BSh) typical of the Cyprus central Measoria plain.

While it could just be a coincidence, it is interesting to observe from the above comparisons that only in areas that experience hot semi-arid climate (Köppen-Geiger class BSh), i.e. Cyprus and the Segura basin in Spain, temporary rivers where further distinguished. In areas that experience hot Mediterranean climate (Köppen-Geiger class Csa) as their driest and hottest climate, no separation between perennial and temporary rivers was undertaken at all or temporary rivers were lumped together in one type (Portugal, Catalan region).

Italy has identified three temporary river types, intermittent, ephemeral and episodic (Ministry of Environment, 2008). From the description of the Italian types it becomes clear that the Italian ephemeral type would correspond, by and large, to type Ih as defined in this study and the Italian episodic type would correspond to the ephemeral type of this study (type E). Taking into account these correspondences of types, the Italian approach to the treatment of their ephemeral and episodic types is similar to what is proposed in this study for types Ih and E, respectively, in Cyprus. The Italian Ministry of Environment (2008) prescribes to exclude their episodic type from monitoring, but to include their ephemeral type; with respect to the latter, they highlight that the peculiarity of these rivers call for attention when including them in monitoring plans. Concluding, the approach in Italy is, apart from differences in terminology, very similar to the proposal of this study. It is worth noting that De Girolamo et al. (2011, p.39) refer in a misleading way to the Italian episodic river type by stating that "the episodic water bodies are excluded by the WFD"; this would indicate that such rivers are not considered at all by the WFD in Italy, while they are excluded only from the monitoring (Ministry of Environment, 2008).

Based on data from 60 rivers in the Mediterranean region, Oueslati et al. (2015) used cluster analysis to identify six distinctive flow regime types; the rivers in their data base included also 13 flow gauging stations from Cyprus covering a wide range of the conditions prevailing on the island. Thus, the results of Oueslati et al. (2015) render themselves for a comparison with the results of this study.

As a general result, they had observed that their six flow regime classes differ in terms of their flow permanence (from perennial to intermittent), degree of flow predictability and flow variability. A comparison with the results of the DProf project yields the following results: (a) From the 13 Cyprus' stations that Oueslati et al. (2015) have classified, three suffered significant impacts on hydrology in the time series they had used and are thus not considered here for comparison. (b) From the remaining 10 stations, it is observed that all the stations classified as perennial, type I or type E by this study, are classified as "perennial", "intermittent" or "harsh intermittent" respectively by Oueslati et al. (2015), while out of the three stations classified as type Ih by this study, two were classified as "Harsh intermittent" and one as "Intermittent" by Oueslati et al. (2015). It is apparent that type Ih of this study has no directly corresponding type in the study of Oueslati et al. (2015) and its stations are distributed amongst "intermittent" and "harsh intermittent".

A more detailed comparison shows that E-type streams elaborated with the TSR method have 325 +/- 40 zero days and a flashiness index (R-B index) of 1.15+/-0.4 and thus correspond to the type "Harsh intermittent flashy" of Oueslati et al. (2015). It is apparent that they call "Harsh intermittent flashy" what are ephemeral/episodic rivers according to the TSR method, while the Cyprus rivers of type E of the DProf project are not classified as "harsh intermittent flashy", but as "harsh intermittent", in their study. A further comparison reveals additional differences between Cyprus stream types and the types of Oueslati et al. (2015). Perennial streams of this study are less flashy (R-B index 0.19 vs. 0.28) and harsh intermittent streams of this study have a shorter dry period (57% vs. 67% zero flow days), while this study's intermittent streams have about the same flow duration (33% vs. 35% zero flow days). However, while both studies are based on stream flow records, different results are to be expected as the results were derived from different methods and also because terminology is not strictly defined thus the naming of actually very similar types may be quite different.

Tzoraki et al. (2014) in their study of the Kouris catchment in Cyprus had found that the TRS plot classified Kryos stream as an Intermittent-Dry (I-D) stream (hydrologically altered) and Kouris and Limnatis as Intermittent-Pool (I-P) streams. Two of the three cases match the outcome of this study while Kouris stream was found to have perennial flow, even if it falls rather close on the perennial/intermittent border on the TSR plot. This discrepancy may well be related to the fact that this study and Tzoraki et al. (2014) had used different time series thus results cannot be expected to be fully congruent. The fact that Tzoraki et al. (2014) had found Kryos stream to be of type I-D (Ih) but hydrologically altered is also confirmed by this study. The stream has reduced stream flow duration because of a stream diversion further upstream that diverts water into a neighbouring catchment, while another inter-catchment water transfer scheme discharges water into it. Under near-natural conditions the stream would be of I-P (I) type. Thus this study yields very comparable results for the single catchment where results are available from Tzoraki et al. (2014).

McMahon (1979) had reported values of mean coefficient of variation for mean annual runoff (CVMAR) ranging between 0.75 and 2.25, with the mean being 1.25, for the Eastern Mediterranean region. This study found values between 0.62 and 1.58, with a gradual increase from perennial to intermittent to ephemeral rivers and a corresponding increase in standard deviation, thus placing Cyprus rivers in the lower range of stream flow variability in the Eastern Mediterranean region, according to the results of McMahon (1979). This finding agrees with the results of Oueslati et al. (2015) who had classified only rivers in Israel and Tunisia in their most variable stream class “harsh intermittent flashy”, with Cyprus rivers appearing in their second most variable class “harsh intermittent”.

With respect to ephemeral rivers, Jacobson and Jacobson (2013) reported a CVMAR of 1.55 from 28 stations on 7 ephemeral rivers in the Namib Desert and described these rivers to be amongst “the most hydrologically variable fluvial systems yet described” (Jacobson and Jacobson, 2013, p.1). The Cyprus rivers of type E of this study have a mean CVMAR of 1.58 and are thus, in terms of variability of annual runoff, very comparable to rivers in the Namib desert.

For a selection of the Namibian stations, Jacobson and Jacobson (2013) report the number of zero flow days to be between 336 and 361, while the corresponding average from this study’s Cyprus E-type stations is 325 +/-40 thus indicating a slightly longer average annual flow period. Still, an examination on station level reveals that the Cyprus dataset certainly includes stations with fully comparable numbers of zero flow days. The catchments corresponding to the Namibian number of zero flow days are located entirely in the lowlands to the east of the Troodos massif representing the “dry end” of the stream type E.

It can be concluded that the studied Cyprus ephemeral rivers, while certainly of a different size class, are still comparable with the Namibian rivers regarding flow variability and flow period length, while the rivers in both studies are certainly ephemeral rivers according to common understanding.

With respect to the change of variability along the river course, Jacobson and Jacobson (2013) observed that Namibian headwater regions exhibited the lowest variability while gauging stations closest to the coast the highest; the same conclusion can be drawn from an examination of elevations and coefficients of variation of the four Cyprus stream types in Table 20 and Table 21 respectively, thus revealing another similarity.

As regards the variability of daily flows, in contrast to variability of mean annual runoff discussed above, data were reported for flow regime classes by Kennard et al. (2010); these results apparently refer to the same study that had already been reported earlier by the same authors (Kennard et al., 2008). A comparison of their results with this study reveals that their extremely intermittent type has a coefficient of variation of daily flow of just above 10, while the Cyprus type E has a CV of 10.7, thus the variability at the "'dry end' of the spectrum of flow permanence" (Boulton, 2014, p.734) is similar. In addition, the CV of daily flow of the Cyprus Ih type is 4.4 which is similar to some of the Australian intermittent types. It is worth noting the different magnitudes of CVMAR and of the CV of daily flow, as mentioned above, in relation to the pertinent quote of Davies et al. (1994, p.488) that "the method of calculation is crucial and there are varying figures in the literature".

With respect to zero flow days, their three intermittent flow classes that "regularly stopped flowing" (Kennard et al., 2010, p.179) all have similar numbers of zero flow days, around 150, while the Cyprus I and Ih types have 120 and 207 respectively. The Cyprus type E is characterized by more zero flow days (325 +/-40) than the Australian extremely intermittent type that has a mean of just below 300 days. Concluding, except the ephemeral streams, the types elaborated by this study do not match well the Australian types of Kennard et al. (2010). The incongruity may arise because Kennard et al. (2010) had used 120 hydrological metrics for classification, amongst which "zero-flow days" is only one of many components (cf. Snelder et al., 2013), while this study employed the TSR tool with only two metrics, acknowledging the importance of the length of the dry period in stream networks that are dominated by temporary flow regimes.

With respect to streams in the Negev Desert, Reid et al. (1998) had reported that these ephemeral stream channels are hydrologically active only 2 percent of the time, or about seven days per year. Such extreme flow regimes are covered by the Cyprus dataset, even though by only one comparable station that is located in the eastern lowland, the "Kokkinokhoria" region, and is characterized by 360 zero flow days, on average; the other E-type stations of this study have longer flow periods. This example and the comparison with Namibian results further above seem to indicate a need to further differentiate what is termed "ephemeral" river in these studies, perhaps into "ephemeral" and "episodic". To this end, I would suggest to tentatively setting a limit between ephemeral and episodic rivers at around 345 zero flow days or approximately 5% of time, based on the experience with Cyprus rivers.

In contrast to the definition of the types after Gallart et al. (2012), the local experience of myself and my colleagues supports that Cyprus I-P (I) type streams dry completely over summer, while Gallart et al. (2012) had written that in this type pools retain water over the whole summer period; still, this is based on my own and my colleagues' experience and not on measured data, because no information on the water retention period of river pools is available.

Table 20 : Catchment characteristics of river types. Averages, standard deviations in brackets

Type code	River flow category (Temporary Stream Regime - TSR[2])	Type name	Altitude + [m]	Geology+ - Coverage of catchment with Troodos mantle and plutonic rocks [%]	Geology+ - Coverage of catchment with Troodos rocks [%]	Geology+- Coverage of catchment with Sedimentary and Quaternary rocks [%]	Annual precipitation 1971-2000 [mm]	Mean water slope [%]	Mean catchment slope [%]
P	Perennial (P)	Perennial mountain streams	1051 (+/- 235)	60 (+/-43)	95 (+/-12)	5 (+/-12)	753.4 (+/-82)	10.8 (+/-4.3)	23.9 (+/-4.3)
I	Intermittent-Pool (I-P)	Intermittent streams	660 (+/- 211)	16 (+/-21)	86 (+/-31)	14 (+/-31)	569.6 (+/-65.9)	6.9 (+/-2.5)	20.9 (+/-5.5)
Ih	Intermittent-Dry (I-D)	Harsh intermittent streams	580 (+/- 208)	11 (+/-20)	98 (+/-4)	2 (+/-4)	479.2 (+/-48.2)	7.5 (+/-3.5)	18.8 (+/-4.6)
E	Ephemeral-Episodic (E)	Ephemeral and/or episodic streams	249 (+/- 146)	1 (+/-1)	45 (+/-41)	55 (+/-41)	378.2 (+/-37.5)	2.2 (+/-1.1)	7.3 (+/-3.5)

+) obligatory factors of Annex II of the WFD

[2] (Gallart et al., 2012, Prat et al., 2014)

Table 21 : Hydrological characteristics of river types. Averages, standard deviations in brackets

Type code	River flow category (TSR regime[3])	Type name	Mean annual flow [m^3/s]	Specific catchment yield [$L/s/km^2$]	Baseflow contribution (Fixed interval method)[4] [%]	R-B index (Flashiness index)[5]	Number of zero days[6]	Mean annual coeff. of variation of mean daily streamflow[7]	Mean coeff. of variation of mean annual runoff (CVMAR)
P	Perennial (P)	Perennial mountain streams	0.257 (+/-0.115)	7.0 (+/-3.9)	84 (+/-6)	0.19 (+/-0.07)	4.5 (+/-11.9)	1.9 (+/-0.7)	0.62 (+/-0.08)
I	Intermittent-Pool (I-P)	Intermittent streams	0.177 (+/-0.146)	3.0 (+/-1.6)	72 (+/-7)	0.34 (+/-0.12)	120 (+/-31)	3.6 (+/-0.9)	0.75 (+/-0.11)
Ih	Intermittent-Dry (I-D)	Harsh intermittent streams	0.090 (+/-0.130)	2.5 (+/-1.3)	65 (+/-14)	0.42 (+/-0.20)	207 (+/-22)	4.4 (+/-0.9)	0.99 (+/-0.28)
E	Ephemeral-Episodic (E)	Ephemeral and/or episodic streams	0.060 (+/-0.053)	0.7 (+/-0.5)	23 (+/-19)	1.15 (+/-0.40)	325 (+/-40)	10.7 (+/-7.9)	1.58 (+/-0.43)

[3] (Gallart et al., 2012, Prat et al., 2014)
[4] (Sloto and Crouse, 1996)
[5] Baker et al. (2004), Richards-Baker flashiness index
[6] Calculated using the IHA software (The Nature Conservancy, 2009)
[7] Calculated using the IHA software (The Nature Conservancy, 2009)

Figure 12: Standardized median monthly flows of streams of the four river types (graphs after Bejarano et al., 2010)

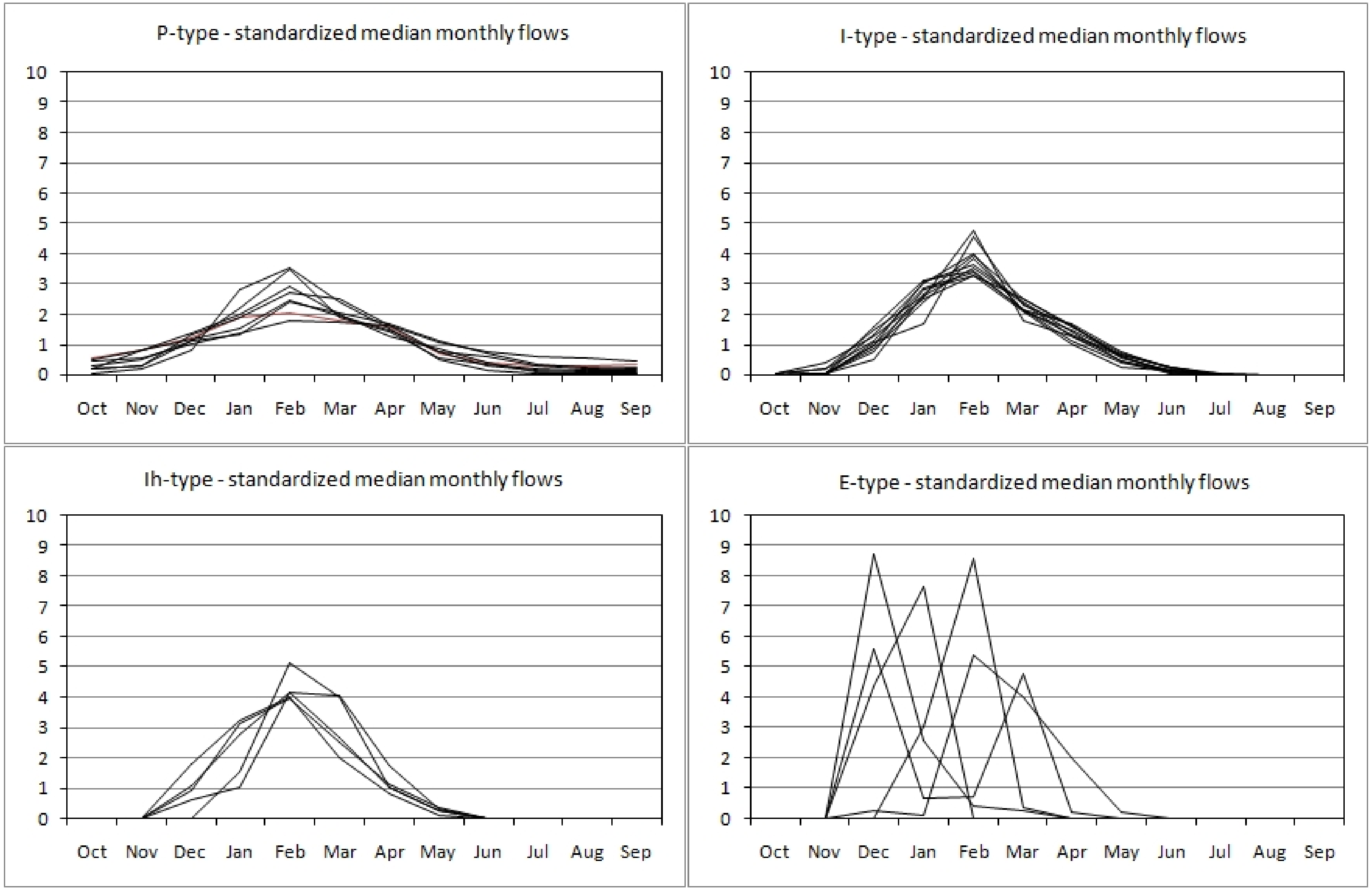
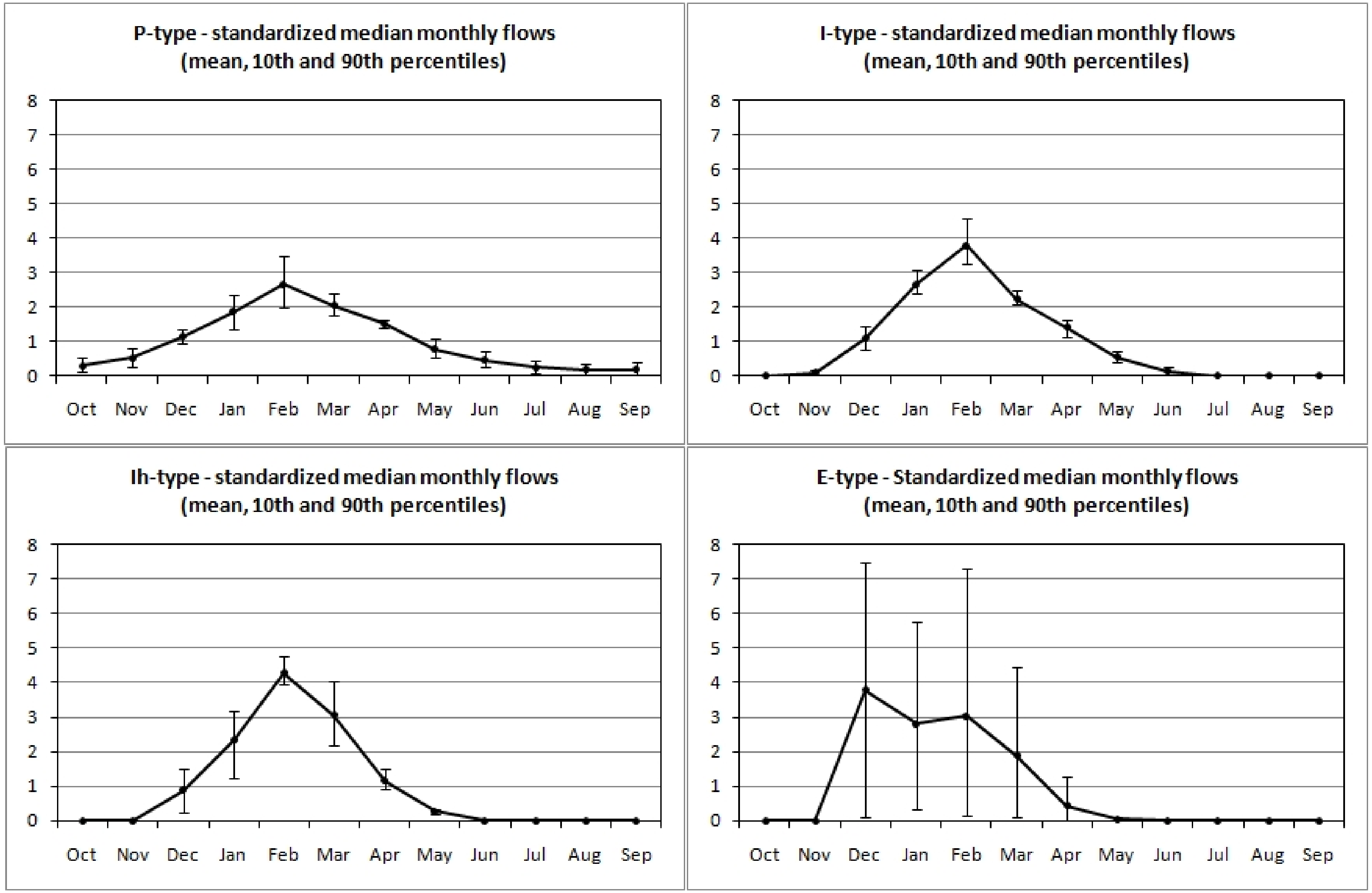


Figure 13: Mean, 10th and 90th percentiles of standardized median monthly flows of streams of the four river types (graphs after Belmar et al., 2011)



4.1.3 Mapping river types onto the river network

The result of this component of the work are **184 typified river reaches of the WFD river network**, each reach corresponding to a single river type (cf. chapter 3.1.2), i.e. to a single Temporary Stream Regime (TSR) after Gallart et al. (2012). The river types correspond to conditions without major hydrological impacts and do not take into account pressures. In other words, the typified river reaches correspond to the Cyprus river network under contemporary near-natural hydrological conditions, and a corresponding map is presented in Figure 14, while Table 22 presents the share of each river type in the whole stream network. As far as I have found out, Figure 14 is the first map that depicts the flow regimes of all main rivers of the island of Cyprus.

Table 22: Share of each river type in the entire stream network

TSR type	**P**	**I**	**Ih**	**E**	**No data***	**Total**
Length [km]	368.8	701.2	567.2	825.5	160.2	2623.1
% of total length	14%	27%	22%	31%	6%	100%

*) “No data” corresponds to the river reaches in those areas of the Republic of Cyprus in which the Government of the Republic of Cyprus does not exercise effective control

In comparison with the stream network that had been identified by WL | Delft Hydraulics et al. (2004) and that had been used for the first RBMP (Karavokyris & Partners Consulting Engineers S.A. and Kaimaki, 2011a), in the typified stream network as proposed by this study (Table 22) the length of perennial rivers has increased from 11% to 14% of the total network length. This is due to river reaches that were identified to have perennial flow, e.g. the perennial part in the middle reaches of Ezousa river, Yialia (Tylliria) river and Kambos river as well as some perennial headwater streams. Because these river reaches had been characterized to have a temporary flow regime before, the length of temporary rivers (types I, Ih and E) is reduced correspondingly in this study.

The distribution among the stream types in those areas of the Republic of Cyprus in which the Government of the Republic of Cyprus **does** exercise effective control is shown in Table 23.

Table 23: Share of each river type in the entire stream network excluding the reaches in those areas of the Republic of Cyprus in which the Government of the Republic of Cyprus does not exercise effective control

TSR type	**P**	**I**	**Ih**	**E**	**Total**
Length [km]	368.8	701.2	567.2	825.5	2462.8
% of total length	15%	28%	23%	34%	100%

As far as the tiers of TSR assignment as well as subsequent changes by expert judgement are concerned (cf. chapter 3.1.4), the shares of each method corresponding to the final stream reach network are shown in Table 24:

Table 24: Shares of methods (tiers) of TSR assignment corresponding to the final stream reach network

Assignment method	**Tier 1**	**Tier 2**	**Tier 3**	**Expert judgement + Tier 4**	**No data**	**TOTAL**
Number of reaches	10	34	98	34	8	184
% of number of reaches	5%	18%	53%	18%	4%	100%
Length of reaches [km]	254.9	556.4	1374.9	304.4	142.8	2633.4*
% of length of reaches	10%	21%	52%	12%	5%	100%

*this number is different from the final river water body network because it includes the river reaches that are impounded by dams; the difference corresponds to the river length flooded by the reservoirs considered as "impounded rivers" for WFD purposes.

In total, 44 reaches (32% of network length) had been assigned their type from gauging station data (Tiers 1 + 2), while 98 reaches (52% of network length) were assigned based on Tier 3, i.e. based on their catchment characteristics by applying the criteria and thresholds determined by this study. A further 34 reaches needed to have their stream type assigned by expert judgement and this corresponds to only 12% of the total network length; for eight reaches no types were assigned due to lack of data – these reaches are located in those areas of the Republic of Cyprus in which the Government of the Republic of Cyprus does not exercise effective control. The above allows concluding that expert judgement decisions refer mostly to small streams (larger number of reaches but small total length) while for Tier 1 decisions the opposite is true (few reaches, but of considerable length each). It is also remarkable that almost 1/3 of the stream network is covered by stream flow data from gauging stations that allows direct assignment of stream type.

For a comparison of percentages of stream types with respect to the entire stream network, the south-western U.S. is suitable according to e.g. Haines et al. (1988). While intermittent and ephemeral streams comprise approximately 59% of the total stream length in the U.S., excluding Alaska, these streams are more highly concentrated in the western U.S. (Nadeau and Rains, 2007). Ephemeral and intermittent streams make up over 81% in the arid and semi-arid Southwest, i.e. Arizona, New Mexico, Nevada, Utah, Colorado and California; the percentages of temporary streams in these states ranges between 66% in California and 94% in Arizona

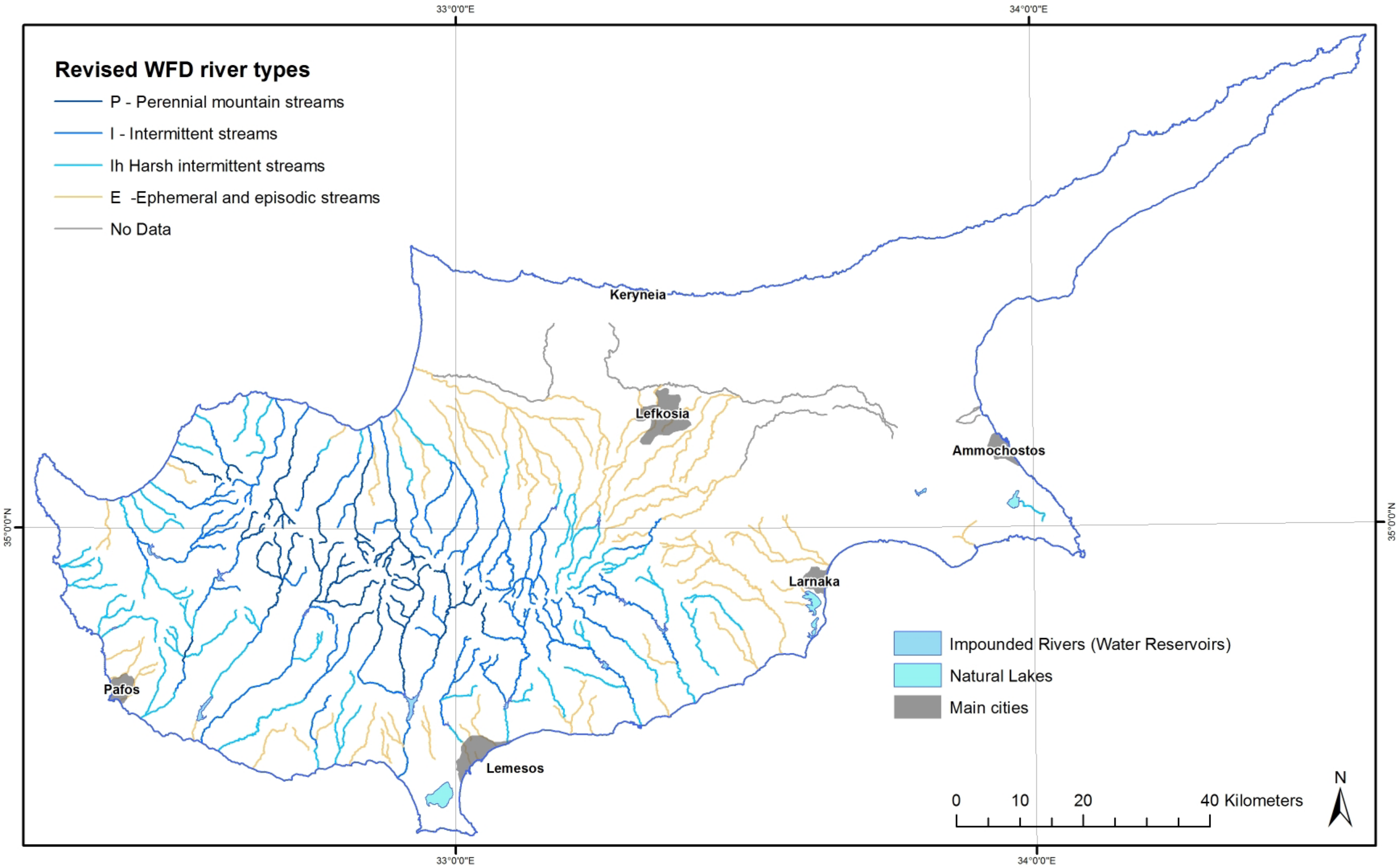
(Levick et al., 2008). The 86% temporary rivers found in Cyprus by this study fall between Utah (79%) and New Mexico (88%) and the character of Cyprus rivers, as it is depicted by the mapped stream types (Figure 14), also compares well with streams in southwestern Arizona where Levick et al. (2008) observed that surface water is found in the mountains, not in the valley floor streams and that perennial and intermittent stream reaches commonly are found in the tributaries, as well as along the main stem of the river (Levick et al., 2008). Nevertheless, it should be noted that there are methodological differences between this study and Levick et al. (2008), whose numbers are based on topographic maps.

The mapping of the perennial reaches of the river network facilitates the identification of refugia where biota find conditions of stream flow or standing pools to survive the dry period. Such conditions are important especially for biota that do not have a non-aquatic phase in their lifecycle or are not mobile, e.g. fish, macrophytes, diatoms. For fish, this means that these critical refugia can now be protected and enhanced. The mapped succession of flow regimes along the entire river course from its mouth to the very refugium, as it was established in this study, is important for catadromous fish species, e.g. the European eel (*Anguilla anguilla*), because this species needs the connection to the sea for completion of its life cycle while it also needs refugia to survive the dry period of the year. This fact gains importance because of two facts: First, the European eel is one of only three native inland fish species (*Anguilla Anguilla*, *Salaria fluviatilis, Aphanius fasciatus.* Zogaris, Chatzinikolaou, et al., 2012a), of which *Salaria fluviatilis* was not located during a recent survey and may be in danger of extinction and *Aphanius fasciatus* inhabits coastal wetlands only (Zogaris, Chatzinikolaouu, et al., 2012b). Second, the European eel has been characterized as “Critically Endangered” on the IUCN Red List of Threatened Species (Jacoby and Gollock, 2014) thus indicating the need for protecting and enhancing its habitats.

The elaborated stream types represent a gradient of stream flow predictability while the difficulty in predicting hydrologic events is directly related to difficulties in planning activities in temporary rivers (Davies et al., 1994). Thus, the mapped stream types provide a clear picture where e.g. monitoring activities can be planned safely beforehand, i.e. in the streams of type I where predictability is high, and to some extent in the Ih type. On the other hand the mapped E type streams clearly represent areas where any planning is difficult and the implementation of activities needs high flexibility.

From a methodological point of view, the approach taken by this study with respect to typology elaboration and its mapping onto the stream network is a classify-then-predict (ClasF) strategy as defined by Peñas et al. (2014), i.e. class membership is predicted to ungauged sites based on environmental data. While this strategy is the most common approach to extrapolate the river type to ungauged sites and to provide a map of flow regimes, this method might pose some flaws. If the distribution of stream gauges is biased, i.e. specific river types are under- or overrepresented (Snelder and J. Booker, 2013), “the cluster step would fail in accounting for those hydrological features underrepresented in the data set” (Peñas et al., 2014, p.3394). Fortunately that is not the case in this study, as Cyprus stream flow data set allowed covering the whole range of flow regimes from perennial to intermittent and to ephemeral-episodic, as described in chapter 3.1.3 and thus the potential flaws mentioned by Snelder and J. Booker (2013) are minimized. This indicates an advantage of the TSR-tool over e.g. cluster methods: On the TSR plot, one can immediately see whether the whole flow domain of permanence is represented by the utilized flow gauging stations, while this information is not discernible from a cluster methodology.

Figure 14: Revised WFD river types, mapped onto the revised WFD stream network



4.1.4 Water body delineation

The findings below correspond to the DProf project's Objective 2: To delineate river water bodies based on the newly developed river typology and on pressures.

The result of this component of the work is the new river water body network. The final number of river water bodies is 245, comprising of 230 genuine river water bodies and 15 impounded river HMWBs, i.e. water reservoirs. The number of water bodies in each new river type as well as details regarding the locations of the WBs are given in Table 25.

Table 25: Number of water bodies in each new river type

River type	River type name	Number of water bodies				
		Rivers			Impounded rivers (Water reservoirs)	Total
		Total	Water bodies located entirely in areas of the Republic of Cyprus in which the Government of the Republic of Cyprus does not exercise effective control*	Water bodies crossing the Green Line	Total	
P	Perennial mountain streams	30	0	1	3	33
I	Intermittent streams	64	2	2	9	73
Ih	Harsh intermittent streams	57	1	2	3	60
E	Ephemeral / episodic streams	76	3	14	0	76
No type	No type assigned due to lack of data	3	3	0	0	3
Total		**230**	**9**	**19**	**15**	**245**

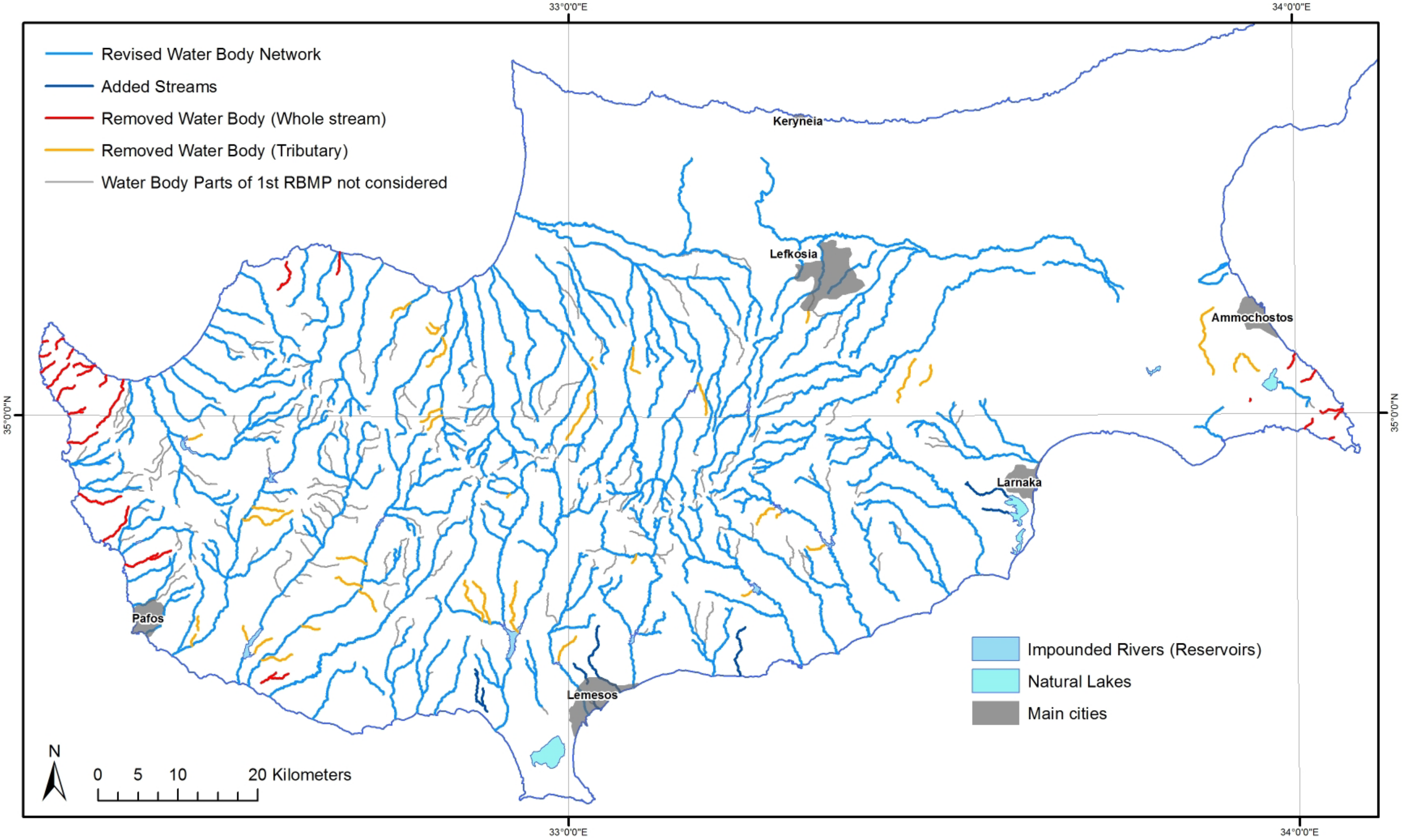
*) These water bodies are located entirely in those areas of the Republic of Cyprus in which the Government of the Republic of Cyprus does not exercise effective control. According to the provisions of Article 1 of Protocol No 10 on Cyprus, attached to the Treaty of Accession to the EU, the application of the acquis is suspended in those areas of the Republic of Cyprus in which the Government of the Republic of Cyprus does not exercise effective control.

With respect to the 216 river water bodies that had been delineated by WL | Delft Hydraulics et al. (2004) and that had been used in the first RBMP (Karavokyris & Partners Consulting Engineers S.A. and Kaimaki, 2011a), this study proposes 230, i.e. an increase by 6%. Percentagewise, this study proposes more water bodies with perennial flow (13% vs. 8%) but less with temporary flow (types I, Ih and E, 87% vs. 92%), in direct correspondence with the shift from temporary to perennial river reaches reported in chapter 4.1.3.

With respect to HMWBs, the same as in the first RBMP were identified; still, this led to a higher number of HMWBs because several single river reaches of the first RBMP had been split into different river types (cf. chapter 3.1.4). Consequently, several HMWBs that had been one single reach in the first RBMP became two or more reaches in the present study and finally, 62 HMWBs were identified corresponding to 49 in the first RBMP. In addition, four WBs were proposed for identification as HMWBs in streams or major tributaries newly added in this study, three natural streams were proposed to be designated HMWB and one natural WB of the first RBMP was merged with an existing HMWB, **bringing the total number of HMWB to 69**. Following from the above, eight WBs are provisionally proposed for final designation as new HMWBs and will have to be evaluated accordingly in the course of the preparation of the second RBMP; these eight WBs correspond to reaches of streams in the greater Nicosia, Limassol and Paphos urban areas, a short section of Pediaios river d/s of Tamassos Dam, a stream greatly modified for flood protection in the Leivadia (Larnaca) area as well as to the most downstream reach of Khapotami river; the eight water bodies are presented in Appendix 11.

The conclusion of the above work allowed establishing the final list of water bodies that are removed by this study from the WFD river water body network of the first RBMP. In total, 67 water bodies of the first RBMP are proposed to be removed; 25 of those correspond to whole streams that were mentioned in chapter 3.1.2 while the remaining 42 correspond to tributaries that did not fulfil the criteria for selection of WFD streams as mentioned in chapter 3.1.2. All 67 water bodies removed are presented in Figure 15 and are given in tabular form in Appendix 12. The 25 removed streams have a total catchment area of $83km^2$ corresponding to 0.9% of the terrestrial area of the Cyprus RBD which has an area of $9250km^2$. Furthermore, the $83km^2$ correspond to 1.3% of the total catchment area of the river water body network proposed in this study, i.e. for the second RBMP.

Figure 15: The revised water body network, streams added for the 2nd RBMP and water bodies of the 1st RBMP that are removed for the 2nd RBMP. The map distinguishes removed whole streams from removed tributaries and also depicts small WB parts of the 1st RBMP that



4.1.5 Elaboration of the water body coding scheme

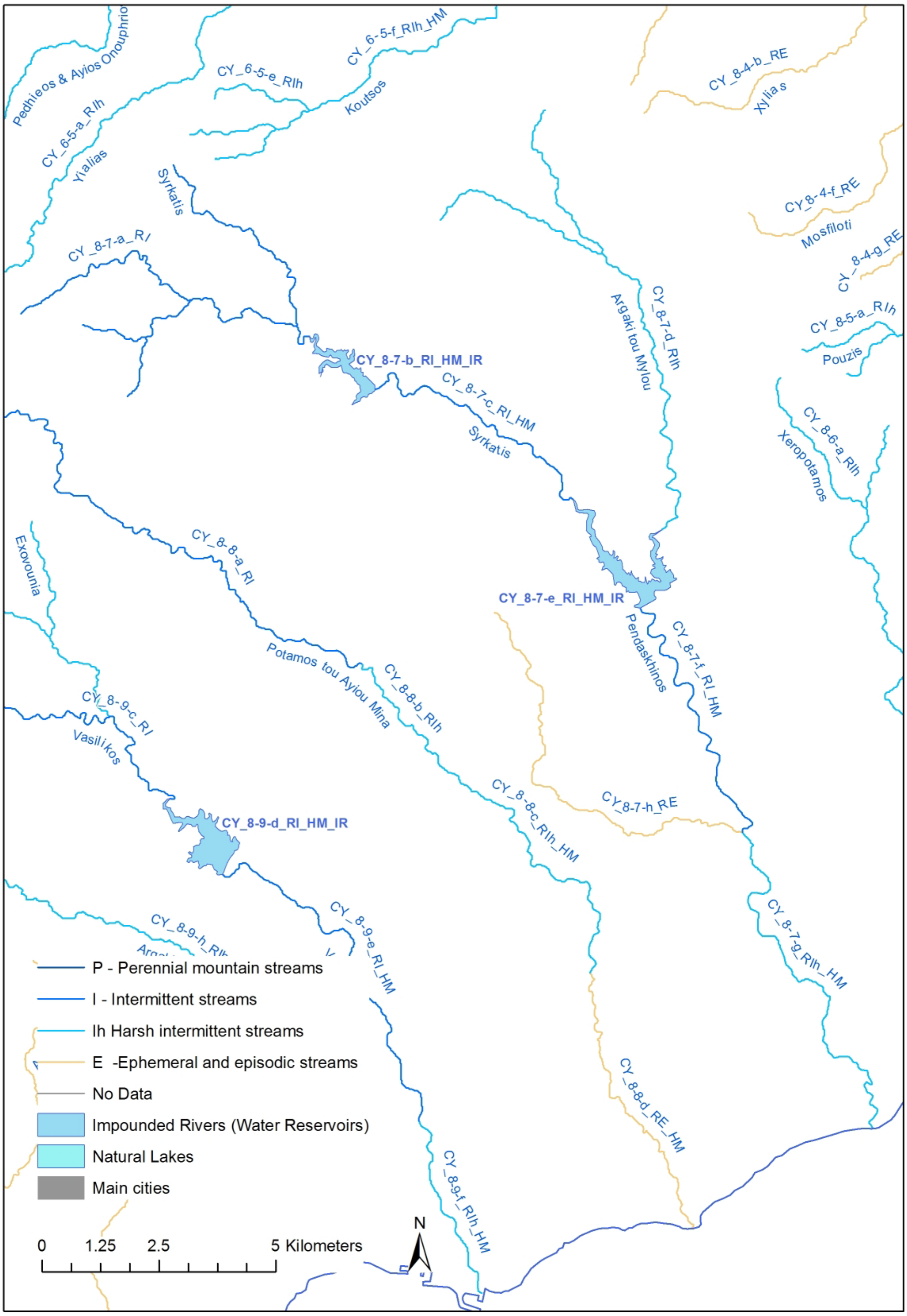
A coding scheme for the newly delineated water bodies was developed as had been described in chapter 3.1.6. The new water body codes are unambiguously distinguishable from the coding system used in the first RBMP, they include the river type and indications for HMWBs and for Impounded Rivers (IR), where appropriate, and they allow for effective and meaningful sorting by the WB code e.g. in tables. An example of water bodies with their codes and names is presented in Figure 16, which shows the Pendaskhinos river (CY_8-7...) and the Ayiou Mina river (Maroni river, CY_8-8...). A map of all water bodies showing their river type, their water body codes and their names is provided as a supplement to this report.

The final list of the 230 river water bodies and their codes, excluding the impounded rivers (water reservoirs), is given in Appendix 13. The table in Appendix 13 gives also, for each water body proposed by this study, the corresponding water bodies of the first RBMP.

In Appendix 14, a list of the 216 water bodies of the first RBMP with the corresponding water bodies of the second RBMP, as proposed by this study, is given.

For purposes of e.g. comparison of status, the correspondence between the water bodies proposed by this study to the water bodies of the first RBMP is an important aspect. In that respect, 189 (82%) of the new water bodies correspond to only one water body of the first RBMP, 12 (5%) correspond to two water bodies of the first RBMP and one corresponds to three water bodies of the first RBMP; 28 (12%) of the proposed water bodies do not correspond to a water body of the first RBMP. The described correspondences however are valid only in one direction, while the correspondences in the opposite direction are as follows. Out of the 216 water bodies of the first RBMP, 99 (46%) correspond to only one of the water bodies proposed by this study, 38 (18%) correspond to two, 8 (4%) to three and 4 (2%) to more than three water bodies; 67 (31%) water bodies of the first RBMP are proposed to be removed (cf. chapter 4.1.4) and do not, thus, correspond to any of the water bodies proposed by this study. The lower percentage of “to-one” correspondences of water bodies of the first RBMP to water bodies proposed by this study, compared to the correspondence in the opposite direction, is due to the fact that a number of water bodies of the first RBMP had been split into more than one water bodies as a result of the new stream typology, while others had been split to achieve improved adjustment to the location and extent of pressures.

Figure 16: Example of water bodies with water body codes and names (Pendaskhinos, Ayiou Mina rivers)



4.1.6 Elaboration of the water body grouping scheme

The findings below correspond to the DProf project’s Objective 3: To elaborate a grouping scheme of river water bodies for improved water status assessment.

The categorization of water bodies into assessment groups was undertaken based on the thresholds and procedures described in chapter 3.1.7 above. The combined pressure levels were assigned to all river water bodies of all four types, i.e. negligible, minor and important “combined pressure level”, yielding twelve groups of water bodies (negligible, minor and important combined pressure level for each of the river types P, I, Ih and E).

The above procedure resulted in all water bodies being categorized according to their combined pressure level and river type. A map of the river water bodies and their combined pressure levels is shown in Figure 17 while a table of all water bodies and their corresponding pressure level is given in Appendix 15; the latter table presents also the pressure levels for each of the three pressure characteristics separately.

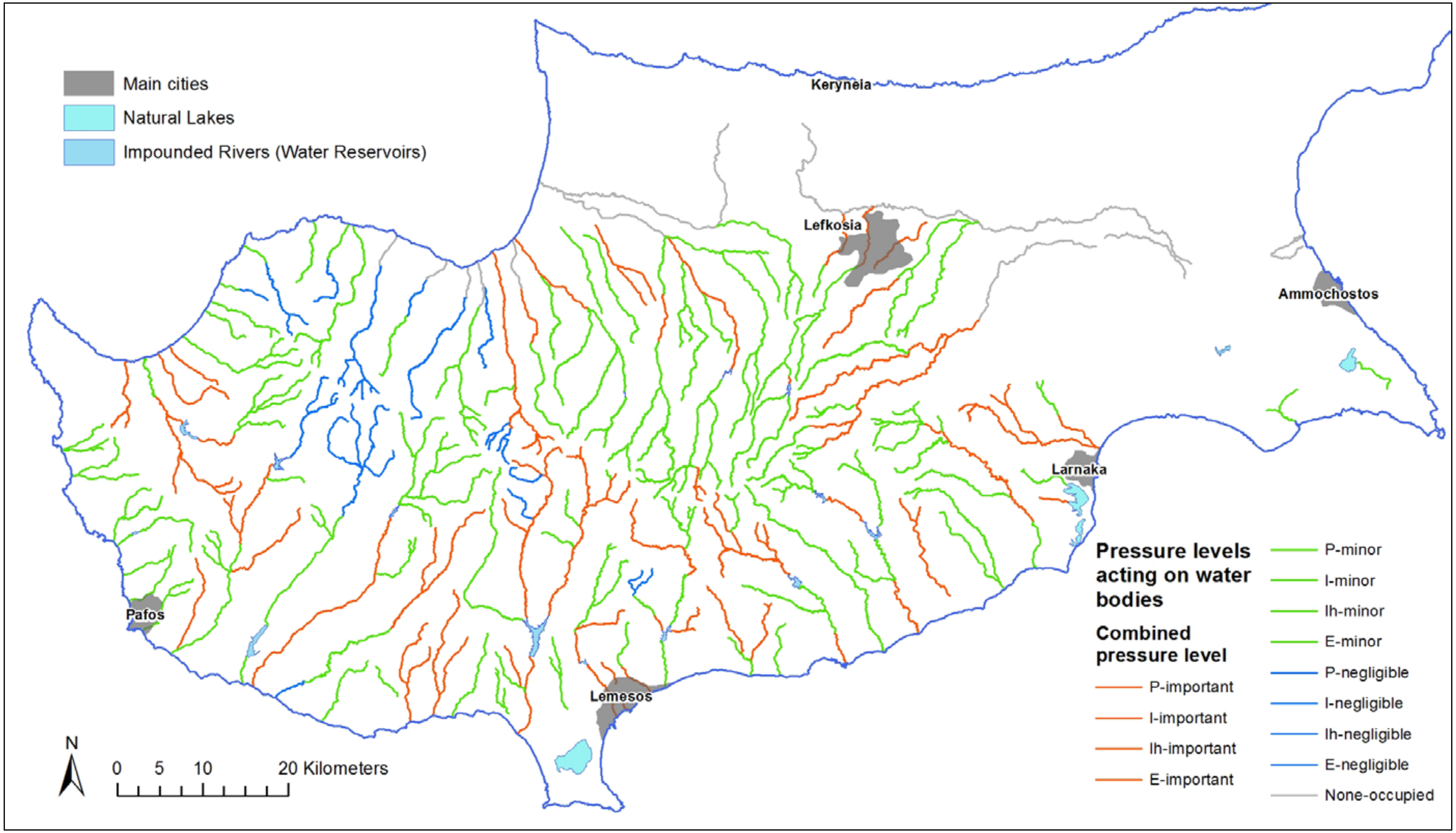
Finally, the monitoring stations, which have valid data for the status classification for the second RBMP, were drawn together according to the assessment group of the water body on which they are located. This yielded the groups of monitoring stations that would be used for the assessment of the ecological status of the unmonitored water bodies in each assessment group. The groups of monitoring stations are given in Appendix 16. It is important to note that, while all stations in one assessment group are, according to the criteria applied by the present study, exposed to the same pressure level, they do not necessarily have the same ecological status as determined from monitoring, because there are outliers with respect to the river system’s response the pressures considered in this study and subsequently to ecological status.

Even though the thresholds of pressure intensities in Table 12 of this study were elaborated only to facilitate the establishment of the assessment groups scheme, a comparison with similar thresholds from the literature is tempting. In any case, published thresholds are rather few and none was found for a similar climate region as Cyprus and for temporary streams. Comparable thresholds were identified only for the parameter “areas of intensive agriculture”; for urbanization, most of the reviewed studies had used the percentage urban area or percentage urban land cover (Donohue et al., 2006, Wasson et al., 2006, Roy et al., 2003, Wang et al., 1997) and thus no comparison with the population density used in this study is possible. Furthermore, no studies with livestock annual Nitrogen load as criterion were located.

This study has found thresholds between 22.5% and 31.7% of “areas of intensive agriculture” that mark the transition from good to moderate ecological status, and the percentage increases with increasing dry period of the streams, i.e. from the perennial to the harsh intermittent type. The reported values in the literature show a quite wide range. Donohue et al. (2006) reported a very low threshold of 1.3% arable land for attaining ‘good’ ecological status in Ireland, while their threshold for pasture is 37.7%. In the Seine-Normandie basin in France, Villeneuve and Sarraza (2009) developed models predicting the ecological status of rivers based on biological indices using macroinvertebrates, phytobenthos and fish data and found that agriculture should not exceed 16% of the catchment area to reach good ecological status, under the condition that urbanized areas cover less than 8% of the catchment. Wang et al. (1997) studied streams in Wisconsin and found little influence of agriculture on habitat quality or biotic integrity in watersheds with less than 50% agriculture. An even higher threshold was reported by Wasson et al. (2006) for France; for high-impact agriculture (arable and permanent crops), their maximum threshold for a good prediction is 80%, but they note that 3/4 of the basins with a predicted “good status” have less than 30% of this land use category in their catchment; thus the basins with 80% agricultural land could be special cases. Fetscher et al. (2013) had tested indices of biotic integrity for their responsiveness to anthropogenic stress including surrounding land uses and they had used 30% agriculture as threshold between “intermediate” and “disturbed” sites, seemingly similar to the Good-Moderate threshold of the WFD. Finally, Allan (2004) states that streams in agricultural catchments usually remain in good condition until the extent of agriculture is relatively high, more than 30%-50%. Any comparison of the reported thresholds needs very much caution due to the different definitions of “agricultural land” used, the different regions under study and also the different indicators of “ecological status” employed by the authors of the above papers. Still, it is apparent that the thresholds found by this study compare well to the threshold of 30% mentioned by Allan (2004), Fetscher et al. (2013) and also by Wasson et al. (2006), while they are higher than the other European results that compare against WFD criteria (Donohue et al., 2006, Villeneuve and Sarraza, 2009).

Concluding, the assessment groups scheme elaborated by the present study constitutes a tool to evaluate ecological status for water bodies for which no data are available in the sense of Reyjol et al. (2014) and the “combined pressure indicator” (CPI) has the capability to improve dealing with combined pressures in Cyprus thus responding to the lack of corresponding conceptual models that had been identified by Garcia and Wasson (2005).

Figure 17: River water bodies and combined pressure levels



4.2 Stakeholder consultation

The findings below correspond to the DProf project's Objective 4: To collect information on anticipated benefits and potential negative effects of the proposed new river water bodies network.

The findings from the five stakeholder consultation sessions are presented in the following chapters. General findings and impressions from each session are reported in chapter 4.2.1, indicative quantitative findings are presented next (chapter 4.2.2) and subsequently the findings from the qualitative analysis of the stakeholder consultation sessions are described (chapters 4.2.3, 4.2.4.).

Finally, issues from the stakeholder consultation that produced feedback for the DProf proposal are reported in chapter 4.2.5 and a summary with discussion is given in chapter 4.2.6.

4.2.1 General findings from the stakeholder consultation sessions

The stakeholder consultation procedure consisted of two action research loops, where the first loop comprised two and the second loop comprised three consultation sessions. Participation was mixed: In the first session only WDD staff took part and in the second session all significantly involved Governmental stakeholders as well as personnel from a WDD contractor had been invited. The third session saw participation from WDD staff and the WDD contractor only, while the fourth event was attended by all significantly involved and affected Governmental stakeholders and the WDD contractor. The fifth event finally was public with wide participation of e.g. environmental organizations, local Authorities etc.

4.2.1.1 First stakeholder consultation session

During the first consultation session, only participants from the Water Development Department participated. A lot of discussion took place and many questions for clarification were raised that gave me the chance to explain my proposal in detail. Questions were asked whenever they emerged and corresponding discussions followed immediately. Questions and discussions were mainly about explaining technical issues while direct comments about benefits and potential negative effects were very rare. Divergent views among the participants were identified with respect to the ideal density of the stream network to be proposed.

From the consultation session, I gained the impression that the stakeholders were ready to accept the proposal "as it is". On reflection, the possibility that this may simply be due to the fact that my colleagues are happy that "someone else is doing the job", and they do not need to get involved, emerged as a potential explanation for this behaviour.

In the session it became apparent that many of the participants, while involved in WFD issues, are not knowledgeable in the technical details of e.g. river typologies and monitoring under the WFD, and thus have difficulties to judge the impact the proposed changes may have. This insight was disappointing because it indicated that I cannot expect much feedback and input for the technical issues of the proposal, not even from WDD staff who are arguably the most knowledgeable in WFD issues; this finding was also a first hint that feedback from stakeholders outside the WDD might be even less.

4.2.1.2 Second stakeholder consultation session

In the second stakeholder consultation all Governmental Departments that are significantly involved in the WFD's implementation and staff of a WDD contractor, an environmental consultancy who had been awarded work that would utilize the DProf outcome, took part. The session developed differently than the first one; there were almost no interrupting questions while I presented the technical proposal, and all significant questions, being very few in total, were raised one after the other, in an almost surprisingly civilized way, afterwards.

I received positive feedback for the proposal from the participants and this was important for me to move ahead with the finalization of the technical proposal. Based on questions from stakeholders, short discussions emerged. Few stakeholders raised issues with respect to potential problems that could emerge from implementing the proposed changes; the questions touched mainly on anticipated objections of the European Commission that could be caused by the proposed change. Questions were raised by participants from the WDD contractor and from WDD officers only; there were neither questions from other Government Departments nor did they contribute to the discussions. For me, the latter fact was on one hand positive, as there was no opposition to my proposal but, on the other hand disappointing because there was no feedback from other Government Authorities.

The lack of feedback from other Government Authorities is especially disappointing because they are managing areas, in some cases vast regions, which are neighbouring the rivers to be managed according to the proposed new river network, typology etc. This may indicate that these authorities, because they do not have to implement the WFD themselves, feel that the proposed changes do not affect them, even though it is clear that streams and neighbouring areas interact through a multitude of processes. Their choice not to contribute may also indicate a general lack of interest, with a high chance that this feeling is increased due to the topic being technical and rather unfamiliar to them. In addition, the fact that some of the Government Departments who did not deliberate at all do not have the "same proximity to the research subject" with e.g. the present WDD staff, may have played a role too; they may have held back in deliberating because they considered that “experts” with more knowledge about the topics were present, in the sense of Finch and Lewis (2003, p.190).

4.2.1.3 Third stakeholder consultation session

Based on the findings from the first two sessions and also because of the tight time frame, it was decided not to hold sessions with other stakeholders for the first loop of consultation sessions, because their potential contribution was considered to be very small as they have even less knowledge about the DProf topics. For the 2nd loop of the consultation process, three sessions were held during which the final results of the technical work were presented and discussed.

In the third stakeholder consultation, participants from the Water Development Department and staff of the WDD contractor took part. During the session, fruitful discussions emerged at several points during the presentation of the technical proposal and at the end of the session. Questions were asked at any point of the presentation and the respective discussions followed immediately, i.e. in that respect the session was very similar to the first session.

From the participants’ reactions and behaviour, I concluded that they were very pleased with the DProf proposal. However, while in the first session I had felt somehow that their positive reactions could merely indicate their satisfaction that “someone is doing the job”, this session left a different impression. I sensed that the participants were happy to see a proposal for a change that would, as was stated by several of them at the end of the session, undoubtedly lead to an improvement in the implementation of the Directive.

In addition, upon reflection it was interesting to observe differences compared to the first session: while in the first session there was a controversy whether the river network should become denser or sparser than my proposal, this time, while discussing the proposal about the DProf components “WB delineation” and “assessment groups scheme”, there was discussion and some critique of certain assumptions and approaches in the proposal, but there were no issues that caused unbridgeable controversies amongst the participants’ views as it had happened in the first session; instead, the participants expressed their concerns while, in the end, they agreed between themselves.

Further reflection about this finding yields the potential explanation that the difference may be due to the difference in technical difficulty between the issues discussed. The issue of river network determination discussed in the first session, i.e. the decision which rivers, reaches and tributaries will become WFD water bodies and which not, is easy to grasp and the anticipation of potential impacts is rather straightforward. For example, it is clear that in a stream that is a WFD water body, the environmental permitting procedure for new alterations of the river is stricter and more laborious than the procedure for a comparable alteration in a river that is not a WFD water body.

On the contrary, the issues discussed in the present third session, i.e. the procedure to delineate, within the river network, the river reaches that become water bodies and especially the grouping of water bodies into groups of similar pressures for the assessment groups scheme, require much deeper knowledge of technical details of the WFD (e.g. the nature of the monitoring results and the classification process) for, firstly, understanding the applied procedure and its limiting factors and, secondly, to gauge any potential impact the proposal may have and to agree or disagree; expressing an alternative approach would need even more specific know-how. This difference in technical difficulty between the issues discussed in the first and third session may explain the different reaction of the participants: A less clear, rather vague, anticipation of potential impact in the case of the technically difficult issues may have kept the participants from insisting on their positions and led them to agreement out of an insufficiently precise idea of the consequences of the proposed scheme. This finding highlights the impact of different levels of technical difficulty on stakeholder reactions and the emergence, or not, of conflicts or diverging positions amongst them.

Other potential reasons for the absence of persistently divergent views in the above instances may be that the subjects e.g. WB delineation and the assessment groups scheme do not entail substantial conflicting interests between the WDD's divisions, and they mostly affect the division in which I myself am working and much less other WDD division present in the session.

The session proved to be a good opportunity for the participants to discuss several problems of the Directive's implementation that are not directly related to the DProf project, but that did commence from some aspects of the project. I did not interrupt in such cases, as it proved that in more or less all cases the discussion after a short while found its way back to the very topics of the DProf project; in some instances, I used a linking statement or a relevant question to steer the discussion back to the project's topics, as suggested by Finch and Lewis (2003).

4.2.1.4 Fourth stakeholder consultation session

At the fourth consultation session all involved and affected Governmental Departments were present. The adjusted methodological approach described in chapter 3.2.2.2 had been implemented and the session sparked lively discussions and a number of questions relevant to the DProf project. The fact that the participants were presented with the actual implementation of the project proposal did certainly facilitate better comprehension of potential impacts of the new river typology, water body network and assessment groups scheme. The questions that were raised referred in many cases to the methodology applied for the elaboration of the DProf proposal and this gave me the opportunity to explain, against the background of the actual implementation of the proposal, the corresponding technical details.

In retrospect, I felt that a brief introductory presentation about the elaboration of the DProf proposal may have helped to avoid some of these questions and the stakeholders would have been better informed before being confronted with the application of the new typology, water body network and assessment groups. On the other hand and judging from the reaction of the participants, all questions could be clarified and they were able to comprehend the applied methodologies, and relate them to the presented actual results, at all times throughout the session. On reflection, the decision to organize the fourth consultation session by presenting to the stakeholders the actual implementation of the DProf proposal was a success and the session provided useful information.

It was interesting to observe that issues which I had already considered closed after the third consultation session were opened again by certain participants, apparently because they had found supporters amongst the stakeholders present at the fourth session, while they had been on their own to put forward their views in the third session. Such a behaviour is explained by Finch and Lewis (2003) who hold that at least three people are required to represent a subgroup, while single representatives may resent the implication that they alone are expected to speak for the subgroup.

In comparison with the previous sessions, no new issues were raised.

In comparison to the second session, stakeholders from a number of Government Departments deliberated, especially from the Department of the Environment. Nevertheless, the majority of deliberations were again from the WDD and the WDD consultant, i.e. from the participants with most pertinent technical knowledge.

4.2.1.5 Fifth stakeholder consultation session

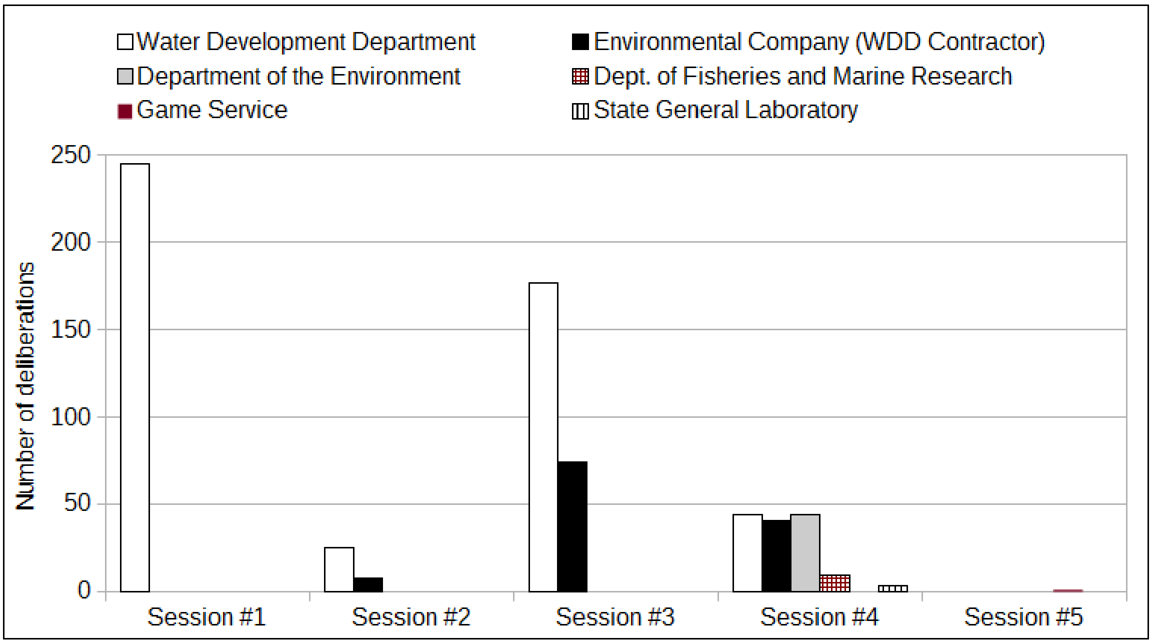
As it was mentioned in chapter 3.2.2.3, this session was a public event and a wide range of stakeholders were present, including also at least two environmental organizations, two large agricultural organizations, the Union of Communities and also representatives from several Municipalities. During the questions' session, the representatives of both environmental organizations made statements and asked questions, as did the representatives of the Union of Communities and of some Municipalities. Still, none of these questions were related to the topics of the DProf proposal, i.e. the proposed changes to the WB network, as compared to the first RBMP, by removal and addition of streams. However, the representative of the Game Service, a Governmental Organization, asked a question regarding the removal of very small water bodies in protected areas that is proposed by this study.

This situation indicates that the specific issues of the DProf project are either too technical or of no interest for stakeholders outside of Governmental Organizations and the general public, thus confirming the doubts expressed by van der Heijden and ten Heuvelhof (2012, p.12) with respect to “the actual value of an open public participation process in the implementation of a highly technological piece of policy”. In addition, the incidence supports the view that the main stakeholders of the changes proposed by the DProf project are Governmental Organizations. It also reassures the decision not to call upon additional stakeholders for specific consultation once it became clear that not even Government Departments, much more involved in WFD issues than non-Governmental bodies, did deliberate (cf. chapter 4.2.1.2). The audio recording also revealed that the question of the representative of the Game Service was not brought forward as an objection to the deletion of these water bodies itself, but rather sought information about potential consequences of it. In any case, the explanation I had provided did not cause any further questions and can thus be regarded as satisfactory for the asker.

4.2.2 Quantitative findings from the stakeholder consultations

The brief quantitative evaluation of the transcripts of the five sessions that is presented below largely confirmed the general impressions that were already mentioned in the descriptions of the sessions in chapter 4.2.1 above. Figure 18 shows the number of deliberations of each institutional stakeholder in each of the five sessions; the fact that all stakeholders were present in sessions #2, #4 and #5, while session #1 was WDD internal and in session #3 only WDD staff and the WDD consultant’s staff took part, has to be considered for its interpretation.

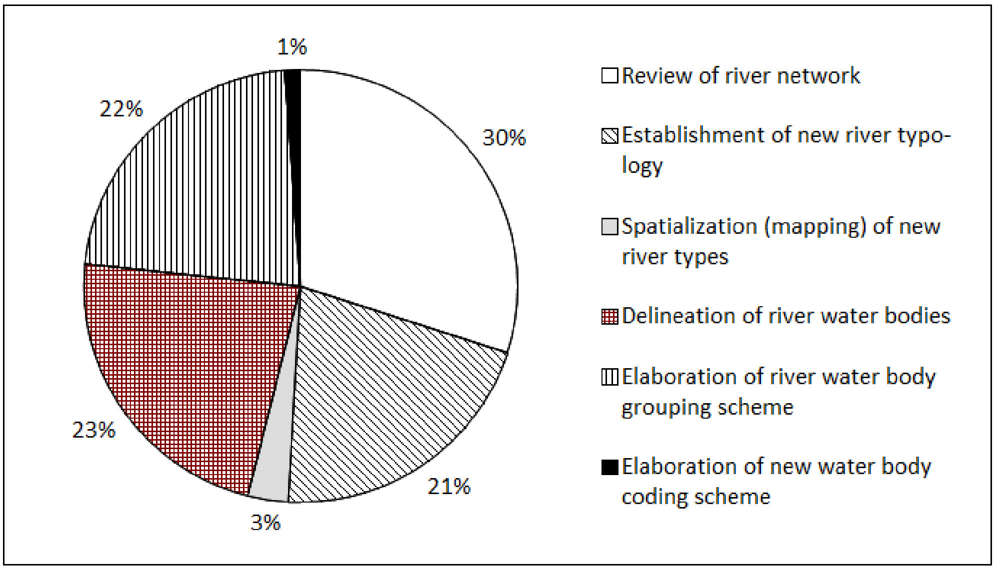
Figure 18: Number of deliberations by institutional stakeholder and per session



With respect to contributions from the different stakeholders in sessions #2 and #4, Figure 18 shows that in session #2 only the Water Development Department (WDD) and the WDD contractor, who had been utilizing the DProf project's outcome in the framework of a contract (ENVECO S.A. and I.A.CO Ltd, 2013), contributed to the discussion while none of the other present stakeholders, i.e. four Government Departments (Appendix 6), deliberated at all. It is also clearly visible from the comparably small number of deliberations that questions and discussions in the 2nd session were generally very limited. In session #4 the Department of the Environment participated to an extent that is at the same level as the WDD and the WDD contractor, while other stakeholders made very few deliberations only. Figure 18 also clearly indicates that the issues of the DProf proposal were of very limited importance in the fifth session, when only one related question was asked.

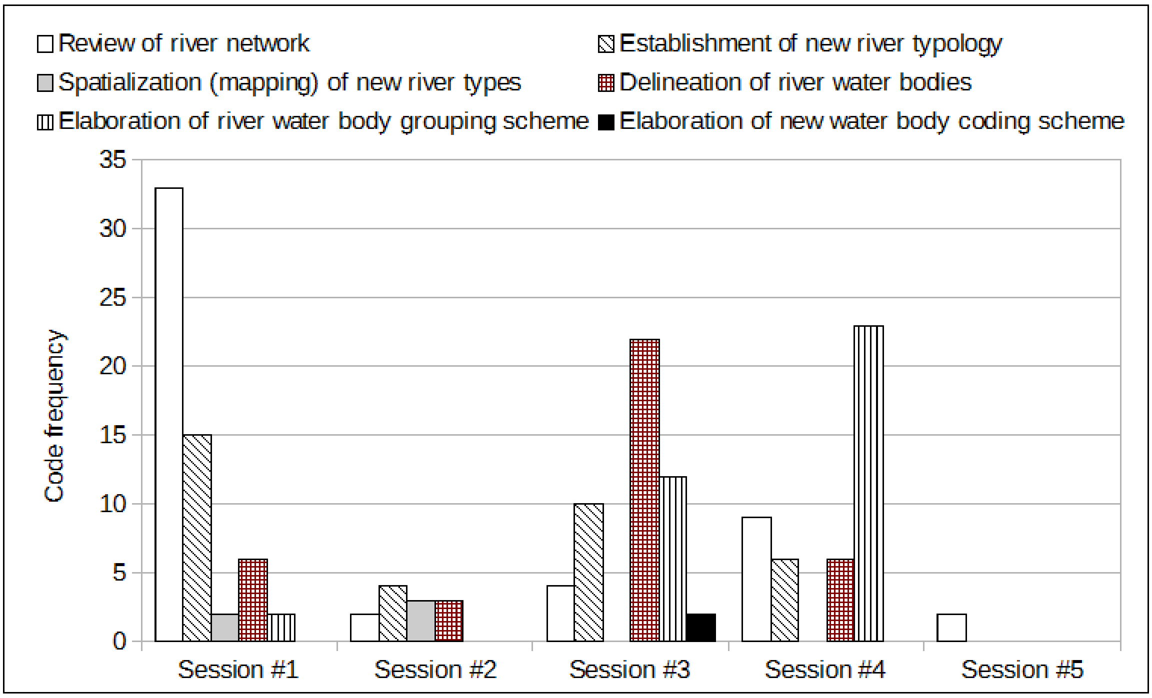
With respect to the Dprof components (cf. Chapter 3) that were discussed in the sessions, Figure 19 below shows that the most discussed topic was the review of the river network, while the three following DProf components reach about the same frequency: the establishment of the river typology, the water body delineation and the elaboration of the assessment groups scheme; still, their frequencies vary widely between the sessions (Figure 20). The application of the river typology to the river network (mapping), a rather difficult and technically challenging task, as well as the minor issue of the new water body coding scheme were only marginal topics as can be seen in Figure 19 and Figure 20. It is interesting to note that the mapping of temporary waterways, which did hardly receive attention by the stakeholders, was highlighted in recent literature (Acuña et al., 2014, Leigh et al., 2015) as crucial for improved management of these rivers and, consequently, as an important topic for future research.

Figure 19: Shares of DProf component codes with respect to the total number of DProf component codes (sums of all sessions)



The distribution, amongst the five sessions, of the frequencies of the codes that identify DProf components is shown in Figure 20. The most frequent topic from Figure 19 above, the review of the rivers network, clearly dominates the first session in Figure 20, and is again important in the fourth session; it is the only DProf component that was discussed in all sessions.

Figure 20: Code frequencies of DProf component codes by session

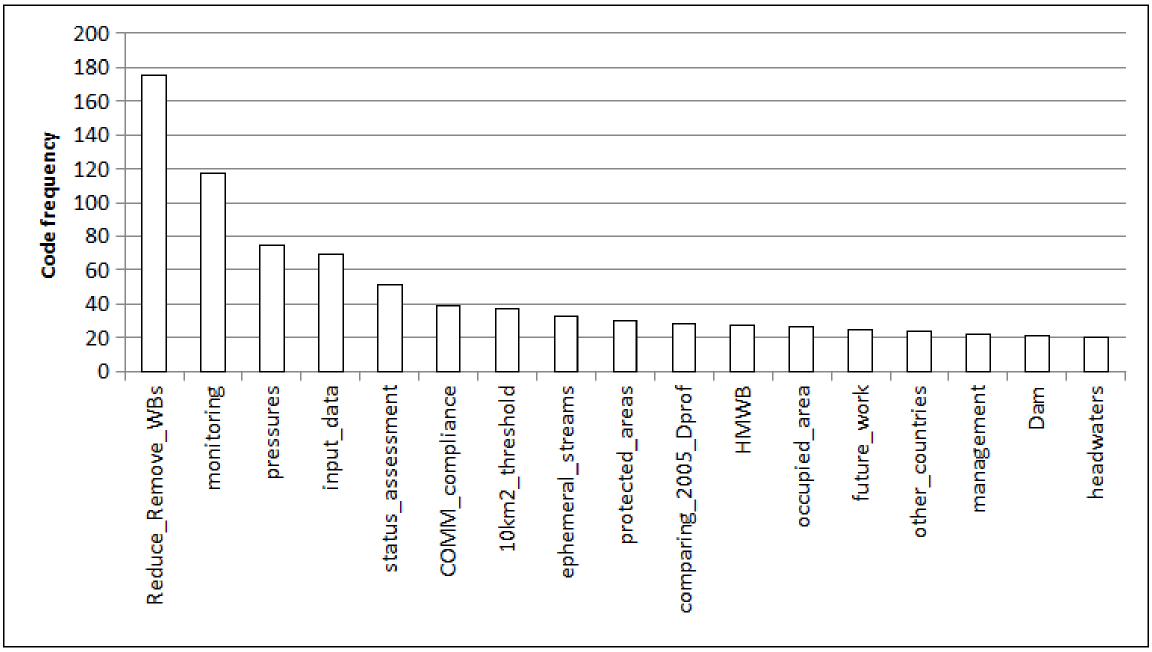


The water body delineation dominates the third session, while the assessment groups scheme is important both in the third and the fourth session; the latter is missing from sessions #1 and #2 because the scheme had been developed entirely after the conclusion of the first consultation loop. The river typology is being discussed in all sessions except #5, but did not dominate any session; this might indicate that it was generally no subject of critique or conflicting views, which would have caused extended discussions, but points to its complementary importance for other DProf components that is reflected by its interwoven appearance within these other topics.

With respect to topic codes apart from the DProf component codes, the most common codes and their frequencies are shown in Figure 21 below.

The topic that was most often raised was whether the number of proposed streams of the network, respectively the number of water bodies, should be reduced by removing some of them. This issue is directly related to the DProf component "review of the river network" and was repeatedly opened up, often as a continuation of other more or less related themes and in particular with respect to streams with ephemeral/episodic flow regime. The second most frequent code refers to the monitoring, which is understandable because many aspects of the changes proposed by the present study are directly related to it. Pressures, the third most frequent topic code, are related directly to the water body delineation and the assessment groups scheme, while the fourth most frequent code, issues of input data, is obviously linked to all DProf components thus explaining its numerous occurrences. Naturally, the theme of "COMM compliance", i.e. compliance of the changes proposed by the present study with the European Directives and with the agreements between the European Commission and Cyprus, was put forward on a regular basis in the consultation sessions. Other codes indicate the main themes that were discussed related to the review of the river network: "10km^2 threshold" (the WFD threshold for small rivers), "ephemeral streams" and "headwaters". As would be expected, a proposal for changing an existing scheme, as the present study, is being compared to the previous scheme and to approaches elsewhere; these comparisons are reflected by the codes "comparing 2005 DProf" (comparing the DProf project to the last corresponding one in 2005) and "other countries". Generally, all these codes would be expected in relation to the scope of the DProf project, with the exception of the code "occupied area" that is certainly specific to Cyprus and fortunately not needed in other parts of the E.U.

Figure 21: Code frequencies of most common topic codes and themes (sums of all sessions)



4.2.3 Qualitative analysis - Anticipated benefits of the adoption of the present study's proposal

The overall impression of the stakeholders' response was that the adoption of the DProf proposal would bring about an improvement:

> "It is obvious that this will bring an improvement" (Senior Executive Engineer #3, 3rd session)

> "This development is for the better, it will help a lot ..." (Consultant #2, 3rd session)

The opinions of the WDD consultants gain special weight because they, at the time of the third and fourth session, had already applied the DProf proposal in practice. In addition to the above, participants considered the chance of opposition against the proposal as minimal:

> "I do not see a possibility that someone may react to that change, all will see an improvement" (Senior Hydrologist #1, 3rd session)

The above view was expressed after I had asked the audience if they identify any potential resistance against the changes proposed by the present study. I had decided to put the question directly as a reaction to the experience from the first consultation loop when nobody had expressed such a possibility. As the reasoning for my question, I explained that the more accurate ecological and chemical status results achieved by applying the DProf proposal may be to the disliking of stakeholders, because WDD can now identify their impact on water bodies with more confidence. Still, the participants could not think of a single stakeholder who might be opposed to the proposed new scheme.

In informal discussions after the conclusion of the third session, stakeholders expressed the view that the issue is very technical and stakeholders would, in the case that e.g. a stakeholder or stakeholder group gets confronted with the failure to achieve the objectives of the WFD due to their activities in a water body or in a group of water bodies, not realize that the "problem" for them had been identified (at least partly) due to the more accurate assessment of water status that became possible because of the new WB network, river typology and assessment group scheme elaborated by this study. In the WBs without monitoring data, where status is determined from the assessment groups, the fact that the water body status has greater accuracy and reliability, due to the proposed assessment groups scheme, invalidates the potential excuse not to take measures "because the status is not reliably established". Still, it was considered very difficult for affected stakeholders to relate this back to the improvements brought about by the DProf proposal, because they would just be facing another map with coloured rivers, and it would need e.g. extended reading through related reports to uncover the impact of the changes proposed by this study.

4.2.3.1 Benefits of the proposed new river typology

The stakeholders had been presented the new river typology (cf. chapter 4.1.2) including the fact that each of the new types corresponds to a defined applicability of BQEs. This provides justification for not monitoring BQEs in streams of type E (31% of network length) and it also offers justification if monitoring results in streams of type Ih (22% of network length) are discarded or if there are no results at all in these rivers, e.g. in drought years. The above benefits were recognized and appreciated by the stakeholders including the fact that in the previous typology, the ephemeral type had not been identified and thus biota seemed to be applicable in the entire WFD river network, but in reality Cyprus had to find excuses why biota were not being monitored in type E streams. A related stakeholder deliberation is:

> "The new typology benefits monitoring and assessment, makes it more defendable, it will allow, in the future, to justify and explain when some classification must remain 'unknown'" (Consultant #1, 3rd session)

4.2.3.2 Benefits for monitoring results

During the sessions it became clear that by adopting the changes proposed by this study (new river typology, WB re-delineation, assessment groups' scheme), monitoring will yield results of greater accuracy and reliability while keeping the monitoring effort at the present level. The majority of the sessions' participants saw this result as a benefit thus acknowledging that the scheme proposed by this study allowed for the determination of the ecological status of all river water bodies, while in the first RBMP 24.5% of all river water bodies could not be classified and had "unknown" ecological status (Karavokyris & Partners Consulting Engineers S.A. and Kaimaki, 2009). Related deliberations are:

> "The results, you mean, will be more correct and representative" (Senior Hydrologist #1, 1st session)

> "The work that was done we consider it to be work that improves the previous work" (Consultant #1, 4th session)

> "We see that this is a system that works very well, the grouping represents the results very well ... we know better what is going on, and in addition, the measures once the time comes to take them, will be more targeted" (Consultant #2, 4th session)

One can see from the deliberations that the stakeholders became more confident about the benefits from the first to the fourth session, which is mainly due to the assessment groups scheme that was presented in the second consultation loop. The stakeholders also acknowledged that the benefits would balance the increase in the number of water bodies, compared to the first RBMP, and keep the monitoring effort at the present level, while results would improve:

> "There is not more workload, on the opposite; it reduces the burden [of management and taking measures] because you have higher certainty in the results" (Consultant #2, 4th session)

> "The monitoring stations do not change, the stations are as they were in the first RBMP, more or less, and in numbers, they are the same, but the network has become more targeted" (Consultant #2, 4th session)

Only one participant seemed to prefer a reduction of monitoring irrespective of its impact on monitoring results:

> "In essence, you are not reducing a little the work you had; again you want to do the same monitoring" (Senior Executive Engineer #1, 2nd session)

It is interesting to note that the participant addresses me personally, by saying "**you** are not reducing a little the work **you** had", due to the fact that I am indeed responsible for the surface water monitoring at WDD and this task constitutes a large part of my overall workload. This instance demonstrates clearly my dual roles in the DProf project and how the two roles are intertwined and become entangled in the course of the study. With respect to the matter raised by the stakeholder, I deem the improvement of the monitoring results that was achieved by applying the DProf proposal to be a major step ahead; especially being able to determine ecological status for all river water bodies and thus achieve full compliance with the Directive in that respect, without a need to increase resources, is considered significant progress. On the contrary, a reduction of the monitoring would jeopardize maintaining this achievement in the future and, therefore, I consider this a non-viable alternative.

4.2.3.3 Identified data gaps

The identification of data gaps by this study, as a result of the elaboration of the DProf proposal, was considered a benefit by the stakeholders, because identified gaps pinpoint directly where efforts should be stepped up in the future to improve monitoring and water management. One stakeholder directly asked for identified gaps:

> "A question ... you, having studied that, what do we have to do to improve the approach, where were gaps identified?" (Senior Hydrologist #2, 3rd session)

I explained that the main gaps identified by the DProf project are in the rivers with harsh intermittent and with ephemeral/episodic flow regime (river types Ih and E) and with respect to quantitative pressure data. With respect to the gaps in Ih and E type rivers, the participant recognized the practical value of the identified gaps:

> ”Ah, you know where you have to put stations!” (Senior Hydrologist #2, 3rd session)

One of the WDD consultants described the relation between the DProf proposal and the identified gaps in a nutshell:

> “With the new river network and the typology that was elaborated by the researcher, we have a much better basis to decide where we need to put a station, this can be done much more targeted.” (Consultant #2, 4th session)

The stakeholders agreed that with the identified data gaps and the proposed assessment groups’ scheme, it is possible to adjust the monitoring network by precisely filling the gaps and thus eliminate previous weaknesses. However, this benefit can only be realized if the DProf proposal is adopted in the end, because the specific data gaps apply to e.g. the specific river types or the specific groups of the assessment groups’ scheme as proposed by this study; with different river types and a different assessment groups scheme this benefit would be greatly reduced.

4.2.3.4 Re-usable methodologies

The consultation sessions reminded the participants that for each WFD management cycle, i.e. every six years, the review and update according to Art.5 of the WFD has to be undertaken anew, and as a result they welcomed the fact that the methodologies of the elaboration of the river typology and of the assessment grouping scheme are documented and could be applied again in the future when e.g. additional or better data become available:

> “The approach exists; we could apply it again in five years” (Senior Hydrologist #2, 3rd session)

> “So, with more data in the future, we could have a better ... [assessment groups’ scheme]” (Senior Hydrologist #2, 3rd session)

4.2.4 <u>Qualitative analysis - Potential negative effects of the adoption of the present study’s proposal</u>

No compelling negative effects were identified in the stakeholder consultation sessions, and even for the concerns that were brought forward by the stakeholders, the chances that they will entail negative effects in practice are considered very small. Nevertheless, the stakeholders’ concerns, as they were expressed with respect to several issues during the sessions, are described below and explanations are provided why the chances of negative effects are considered to be very limited.

Dissent in rather fundamental questions between stakeholders was identified with respect to several issues discussed in the course of the consultation sessions and this is considered an important finding of this study. Such dissent may pose a threat to the efficient and productive execution of the missions and tasks of the stakeholders' organisations. Important topics of dissent are the ideal density of the stream network (chapter 4.2.4.7) and the treatment of ephemeral/episodic rivers (chapter 4.2.4.8).

The theme whether the number of proposed streams of the network, respectively the number of water bodies, should be reduced by removing some of them (cf. chapter 4.2.2) will not be described separately, even though it was found to be the most frequent topic code (Figure 21). This subject weaves in and out of many other more or less related themes (*sensu* Ritchie and Lewis, 2003), which are described in the following chapters, and thus the specific theme is present throughout these chapters without a separate chapter being dedicated to it.

4.2.4.1 Removal of very small streams in protected areas

Concerns were voiced by few isolated stakeholders that the removal of very small streams from the WFD river network in protected areas could cause opposition from the European Commission to the proposed stream network. The removal of these rivers, which had been WFD water bodies in the first RBMP, is suggested by the DProf proposal for a number of very small coastal streams in Natura 2000 areas, e.g. in the Akamas peninsula. One stakeholder expressed her concerns as follows:

> "But couldn't there be complaints from the E.U. that rivers in Natura 2000 areas should be included 'by definition'?" (Senior Hydrologist #1, 1st session)

Another stakeholder did not express concerns about these rivers' removal but was interested about the potential effects of it:

> "... about the removal of some water bodies, even the small percentage that you have mentioned, in practice what does this entail especially because most of them are in protected areas, does this entail anything? It may not mean anything but I would like to know." (Game Fund Officer #1, 5th session)

In response to the above concern I explained the logic behind the removal of these very small streams from the stream network. Firstly, the strict application of the quantitative criterion suggested in WFD CIS Guidance Document no. 2 (European Commission, 2003a) for the identification of WFD rivers justifies the removal of streams with catchment area smaller than $10km^2$, and a number of other E.U. Member States had also applied this threshold, e.g. Ireland (Office of Environmental Assessment, 2005) and Scotland (SEPA, 2005); consequently, chances of complaints from the European Commission are negligible. Secondly, this study includes also a proposal, based on and entirely compliant with the relevant WFD CIS Guidance Document no. 2, for the protection of these very small streams in the future (cf. chapter 4.1.1 for details). Thirdly, these very small rivers had caused problems in the past because their small size and, by the majority, ephemeral/episodic flow regime do not allow the existence of BQEs and hence, the status of these small streams cannot be assessed. This in turn created the need to explain why the status of these rivers could not be established, and the removal from the stream network would solve this problem. A participant with practical experience in BQE monitoring in Cyprus agreed with the DProf proposal to remove these streams because he anticipated that retaining these very small streams would leave the problem unresolved:

> “You may have the problem you had before” (Consultant #3, 3rd session)

It is worth noting, with respect to the above, that at the fifth stakeholder consultation session, where I had presented the proposed removal of these small streams from the WFD stream network, all main Cyprus Environmental Organizations were present but no opposition to the proposal was expressed; in fact, in their deliberations they did not refer at all to this topic.

Consequently, with respect to the concerns mentioned above, I consider the chances of opposition from the European Commission to be negligible while future opposition from national stakeholders seems very unlikely.

4.2.4.2 Completely new river network in comparison to the first RBMP

The stream network had been created entirely “from scratch”, i.e. compared to the corresponding network of the first RBMP, streams have been removed, new streams have been identified and added and the network’s geometry is not congruent with the corresponding one of the first RBMP. This fact caused the concern of few isolated stakeholders in the first session:

> “Is there a chance that the European Commission will complain, because it is very different?” (Senior Executive Engineer #1, 1st session)

This was considered very unlikely by the other participants, and I explained that my approach was to put the proposed stream network on a sound and fully WFD compliant basis (cf. chapter 3.1.2) but at the same time to create a network that does not look “dramatically different” from the one of the first RBMP; for example, in the headwaters it should have about the same detail. No further concerns were expressed about this issue during the following consultation sessions.

With respect to the streams that had been newly identified by the present study, i.e. they had not been included in the first RBMP, concerns were also expressed:

> "The European Commission could say you had not found this before, so what are you telling me now?" (Senior Executive Engineer #1, 1st session)

I explained that the stream identification is based on a consistent, documented and well justified methodology (cf. chapter 3.1.2) and another participant found this sufficient to resolve the concerns:

> "If we can justify the way of selection, the European Commission cannot criticize" (Senior Hydrologist #1, 1st session)

With respect to the above issue and concern of stakeholder "Senior Executive Engineer #1", the development of this stakeholder's position on the issue during the consultation loops is worth mentioning. After the statement of the first session cited above, the next deliberation on the same issue in the third session was quite different:

> "The European Commission does not care, they will rather see that positively as we are adding, because when you add water bodies they are sure that you will be monitoring them, but if you remove they ask you to justify" (Senior Executive Engineer #1, 3rd session)

In the fourth session, when the issue of newly identified streams, as compared to the first RBMP, was discussed again, I repeated my view that the strict application of a quantitative criterion is the best way to justify both the removal but also the addition of streams and to avoid any critique and opposition from the European Commission; this time, the stakeholder's response resembled her opinion of the first session:

> "But we had said to the European Commission that we will remove! [and not add]" (Senior Executive Engineer #1, 4th session)

It becomes apparent that the specific stakeholder, who was the only one who deliberated on this issue in several sessions, changed her opinion from "concerned" to "neutral" and back to "concerned". This finding may indicate that stakeholders deliberate without a robustly formed position with respect to the topics of the consultation sessions, and this is probably because they do not come into contact with these issues frequently enough for the development of a stable opinion about them. Therefore, their respective deliberations may be influenced mostly by the momentary atmosphere at the time of the specific discussion, because they do not have a robust personal opinion on the issues.

In relation to the above issue of streams newly identified by this study, a pertinent comment was made to highlight that the second RBMP, which will be based on the DProf proposal if the latter is adopted, will be examined more rigorously by the European Commission than the first RBMP:

> "The first time the European Commission gave some flexibility to many countries ... but I think in the 2nd cycle it will not be that friendly ... and if some things were declared in the first cycle, and we believe it was wrong, so we have to argue with evidence now and we tell the reasons why" (Senior Environment Officer, 4th session)

This opinion indicates that any changes proposed in the second RBMP, in comparison to the first RBMP, should be well justified and documented. I am confident that this is certainly the case with the DProf proposal, through the application of the methodology that is documented and justified in chapter 3.1. Consequently, with respect to the concerns mentioned above, I consider the chances of opposition from the European Commission to be minimal, while small differences between stakeholders are noted.

4.2.4.3 Impact on the results of the intercalibration exercise

I had expected this issue to raise concerns, because river types are directly related to the so-called "type specific reference conditions" (WFD Annex V), which are fundamental components of ecological status assessments under the WFD and are, consequently, also fundamental for the intercalibration exercise (IC); Cyprus had successfully completed the exercise (European Commission, 2013b) and an inconsiderate change of the river types could at worst invalidate this achievement. Thus, despite the fact that the raised concerns were few, they refer to an issue of great potential impact:

> "How will these changes impact on intercalibration ... with the results we achieved up to now?" (Senior Executive Engineer #3, 2nd session)

In response, I explained why I am very confident that the Cyprus IC results will not be challenged (cf. chapter 3.1.3 above for the complete argumentation); apparently the explanations did not fully convince the participant, and the discourse continued:

> "So we don't need a new Intercalibration Exercise ..." (Senior Executive Engineer #3, 2nd session)
>
> "No way, we will not do it" (Researcher)
>
> "...we will not do it..." (Senior Executive Engineer #3, 2nd session)

> "If they ask for it, we will answer that there is no reason ... and there are no new stations, the stations are the same" (Researcher)

> "Ok" (Senior Executive Engineer #3, 2nd session)

Here the further clarifications and the expression of my own certainty that the chances of negative effects on the Cyprus IC results incurred by the changes in the typology are minimal, resolved the stakeholder's concerns. With respect to the concerns mentioned above, I consider the chances of opposition from the European Commission to be minimal while concerns of national stakeholders were resolved.

Upon reflection, however, it becomes clear that the adoption of the proposed new typology, despite the above concerns with respect to the intercalibration results, will certainly lead to a more accurate and compliant application of the latter. This is expected because the proposed new Cyprus stream types are a much better fit to the IC types. In particular for temporary rivers, the separation of the ephemeral/episodic rivers into a type of their own eliminates their "interference" with the intermittent rivers of type I and Ih, which can be monitored for WFD biota, while this is not possible in rivers of type E.

4.2.4.4 Impact on monitoring

Because one major purpose of each water body is to have its status assessed through monitoring, a new water body network is likely to have an impact on the existing monitoring programmes that are in place to assess status. Thus, while benefits of the DProf proposal for monitoring were acknowledged (chapter 4.2.3.2), concerns about negative impacts were also raised by some stakeholders. The concerns were sparked by the fact that the present study proposes an increase of the number of river water bodies from 216 in the first RBMP to 230 for the second RBMP (cf. chapter 4.1.4 above), even more so because in the first RBMP the removal of 62 small water bodies from the water body network had been proposed (Karavokyris & Partners Consulting Engineers S.A. and Kaimaki, 2011b). The stakeholders expressed their concerns, e.g.:

> "The question is how will we monitor all these, but you are concerned how we will protect the rivers" (Senior Executive Engineer #1, 2nd session)

It is worth noting here that the participant precisely recognizes that more water bodies could mean an increase in required monitoring effort, but that it would also bring about a higher level of protection for the water systems; in addition, it is worth noting that the participant refers to the protection of rivers like it would be my personal concern ("...**you** are concerned..."). In that respect, while I certainly promote the Directive's objectives for river protection, it is also a fact that I am responsible for rivers monitoring at the WDD, i.e. any increase in monitoring would mean an increase of my own workload.

As the session went on, I explained that monitoring effort would approximately stay the same, as the increase in number of water bodies would be balanced by the improved efficiency resulting from the improved river typology, and the participants seemed to be convinced, e.g.:

> "So there will not be much additional workload for monitoring" and "we do not win something but we do not lose something" (Senior Hydrologist #1, 2nd session)

For the second consultation loop, I had finalized the assessment groups' scheme (cf. chapter 4.1.6) and presented it to the stakeholders, together with the new typology and water body network and I pointed out the improved quality of the monitoring results. For example, the application of the DProf proposal's scheme allows for the determination of the ecological status of all river water bodies for the second RBMP, while in the first RBMP almost a quarter of the water bodies remained in "unknown status". The stakeholders acknowledged the proposed scheme's advantages:

> "The fact that we increased the WBs does not mean the monitoring burden will increase" (Consultant #2, 4th session)

Other participants precisely recognized the benefits of the assessment groups' scheme in relation to the new typology and water body network, namely that within each river type only a certain "critical number" of monitoring stations is required to carry out the assessment; once these stations are operational, the actual number of water bodies of the specific type that are assessed based on their results can be increased without further increasing monitoring efforts:

> "The number of water bodies does not have a relation to the monitoring cost, there is no relation ..." (Consultant #1, 4th session)

> "Once the grouping is done ... you increase as many as you need and want your water bodies, the [monitoring] stations stay the same" (Hydrologist #2, 4th session)

Still, other stakeholders maintained their positions of the first consultation loop and continued to support that the increase in the number of water bodies might lead to problems with the monitoring. They went on to request to remove ephemeral streams from the network, to join them with other water bodies etc., and the discussion went on without progress, in part also due to the limited capacity (cf. De Stefano, 2010) and lack of specific technical knowledge of some participants who nevertheless continued to put forward questions and suggestions (cf.

chapter 4.2.4.8). This led one stakeholder, who has practical experience in WFD monitoring, assessment and management, to express her annoyance about the unfruitful discussion:

> "Well, if with this new scheme, no problems with the monitoring are created, why should we discuss about reducing? ... why do we discuss? I think we should go ahead, and if new data emerge, or new pressures, then we adjust correspondingly" (Fisheries and Marine Research Officer, 4th session)

This caused a response by a laboratory that analyzes water quality samples for the WFD monitoring programmes:

> "Let me answer, if you say why we should not continue the monitoring, I don't know how well you realize how much this costs" (Senior Chemist, 4th session)

Still, the difficulty to justify the removal of water bodies was considered to be very high:

> "o.k., but ... we have to justify why we remove water bodies! To justify when you remove water bodies, you need very strong arguments!" (Fisheries and Marine Research Officer, 4th session)

The analysis of the discussion and the positions taken by the various stakeholders revealed that interestingly, stakeholders who have practical experience in WFD monitoring and assessment are in favour of keeping the DProf proposal, as I presented it, while other participants who do not have detailed knowledge of the issues are in favour to remove water bodies. One explanation of this finding could be that without detailed knowledge of the WFD's technicalities, it is difficult to acknowledge the benefits of the proposed scheme, especially the interrelations between typology, water body delineation and assessment groups' scheme, while removing streams seems to be a straightforward way to reduce workload. Another explanation could be that uninvolved stakeholders do not care about monitoring results as it is not part of their responsibilities and they thus easily support any reduction in effort, while stakeholders who deal personally with these issues may better recognize the severity of removing water bodies from the WFD network. In addition and on a more personal level, the latter may feel that reducing their monitoring work in certain water bodies would reduce the geographical coverage of their knowledge base, thus reducing the chances of e.g. being consulted for their expertise. With respect to the deliberation of stakeholder "Senior Chemist", brief reflection reveals that she is simply advocating in favour of her organization's interest: the State General Laboratory does not bear any responsibility for the final assessment of water status, i.e. gaps in the monitoring results or less reliable results would not have any impact on it, while reduced monitoring would reduce the workload of her organization.

Following the above exchange of contrary views and even though it had been shown before that the number of water bodies is unrelated to monitoring efforts within each river type, the differences could not be entirely bridged. However, I did not proceed to change the DProf proposal, because I considered it preferable to maintain monitoring efforts and costs as well as the geographical coverage of monitoring results at the existing level, instead of breaching and invalidating the quantitative $10km^2$ criterion for stream identification by removing streams. Such a change to the DProf proposal would have invalidated the justification for the removal of streams proposed by the DProf proposal (cf. chapter 4.2.4.1) and would have risked future opposition to, or the rejection of, the proposal by the European Commission, while at the same time reducing the area covered by data from environmental monitoring.

Another concern of the stakeholders was about the continuity of time series of data that had been collected for the water bodies of the first RBMP, under the new scheme proposed by this study:

> "Because now you created new water bodies, how will you query the information?" (Senior Hydrologist #1, 3rd session)

I explained that all monitoring data is stored at station level, not on water body level. Consequently, no data is being lost because all data would simply be used for the new corresponding water body. Still, the stakeholder was concerned about the continuity of aggregated data on water body level:

> "...by selecting the water bodies...you cannot compare it with the previous?" (Senior Hydrologist #1, 3rd session)

For the purpose of comparing the data on water body level, e.g. the ecological status, between the first and second RBMP, the DProf proposal includes correspondence tables that show the relation between water bodies of the first and the second RBMP (cf. chapter 4.1.5). From the proposed 230 water bodies, 82% correspond to only one water body of the first RBMP and, therefore, there is a good degree of correspondence for making comparisons.

Still another concern of a stakeholder was whether with the new stream network and especially as a result of removing some streams (cf. chapter 4.1.1), monitoring stations were "lost" for WFD purposes and thus their time series are no longer available for long-term assessment of river status. I explained that this is not the case, because monitoring stations are on larger rivers while the removal affected very small streams only.

Concluding about the stakeholders' concerns mentioned above, it is noted that the large majority of the stakeholders were convinced that there will be no negative effects on monitoring and in particular no increased workload; still, few stakeholders' doubts could not be resolved. No negative effects that could come from the European Commission were identified.

4.2.4.5 Inclusion of HMWBs in assessment groups of natural rivers

During the discussion of the assessment groups' scheme and specifically with respect to HMWBs, concerns were raised about the approach I had taken (cf. chapter 3.1.7) to place HMWBs into groups of the flow regime type (river type) that correspond to their current impacted hydrological regime, together with natural water bodies:

> "But if we do that ... we will never improve the status, because we follow the types, I mean the resulting [current] types" (Senior Hydrologist #1, 3rd session)

> "But I don't know if the European Union wants it like that" (Consultant #1, 3rd session)

Some discussion emerged and I explained that in the particular case of these water bodies, i.e. in rivers downstream of dams where the hydromorphological impact is purely the drastic reduction of flow and because Cyprus has not yet developed a dedicated method to assess the Ecological Potential, i.e. the ecological quality, in these water bodies, the selected approach seems to be the most feasible. This conclusion arises because it is desirable that the assigned natural type (i.e. the type before the hydromorphological alteration, visible in the WB code) specifies how a particular HMWB should be under natural conditions, because it relates to the 'reference conditions' and not to sites suffering impact (Logan and Furse, 2002). On the other hand, the assessment group into which a specific HMWB is placed gives the current flow regime type and thus the difference, the deviation from the natural type, is directly observable. The approach is furthermore justified because it reflects that due to the importance of the reservoirs' water uses (mainly drinking water supply but also irrigation), no mitigation measures that would bring about an improved hydrological regime downstream of the dam could be taken in the assessed period. Consequently, for the period under study, the current hydrological situation is the one that has "no significant adverse impact on use" (WFD Art. 4.3.a) and thus corresponds to Good Ecological Potential (GEP), and the HMWB is assessed according to this flow regime type. The discussion allowed the stakeholders to anticipate the purpose and significance of HMWBs under the WFD:

> "That is why the HMWB designation is so important!" (Consultant #1, 3rd session)

If the assessment of feasible mitigation measures changes, e.g. in case it becomes possible to release ecological flows, then the GEP must be adjusted too, respectively the HMWB must be assessed in an assessment group of the new corresponding flow regime.

The session concluded that the approach is not ideal but under the existing preconditions it is the best available option; to this end, no alternative approaches were suggested by the stakeholders and, therefore, the DProf proposal remained unchanged. The root of the identified problem is the lack of a GEP assessment method and not the DProf proposal; still, this represents a weakness that could at worst cause sanctions from the European Commission for the lack of such assessment method, if their assessment of the second Cyprus RBMP investigates in detail the methods applied by Cyprus, because the weakness is probably not identifiable by a superficial inspection.

4.2.4.6 Water body delineation at boundaries of protected areas

There was disagreement amongst the stakeholders whether river water bodies that cross protected areas (e.g. Natura 2000) should obligatorily be split at the boundaries of these protected areas, so that the water bodies' boundaries would coincide with the boundaries of the protected areas. While the WFD does not require such boundary congruence, it still requires for protected areas to be considered for water body delineation. Different opinions were expressed; some were in favour to delineate separate water bodies e.g.:

> "If you had a SPA area, along the river, this would not become a separate [water body] ... no? ... because there is a separate management plan of the [protected] area" (Senior Hydrologist #2, 3rd session)

Other participants were more reluctant but proposed to decide case by case:

> "It is not necessary to be separate" ... "if there is a water body that has pressures and is in a Natura 2000 area, perhaps in such cases it makes sense to split a water body, because from a management point of view, you can take some additional measures" (Consultant #2, 3rd session)

Some participants regarded issues of protected areas out of the scope of the WFD and were opposed to taking into account protected areas at all for the water body delineation, because this would increase the number of water bodies:

> "This is an over and above measure" (Senior Executive Engineer #1, 3rd session)

> "Nobody is stopping you to manage it according to the Natura area. WFD has a specified scope, if you have something in addition, to manage it better, you will do it in addition" (Senior Hydrologist #1, 3rd session)

The above views demonstrate how the group context of the consultation sessions provides the opportunity to explore difference, divergence and diversity in stakeholders' opinions as described by Finch and Lewis (2003) and Robson (2002). Comparing the above different opinions with the methodology that was applied to delineate water bodies in relation to protected areas (cf. chapter 3.1.5), I considered the DProf proposal to be midway between the views of the stakeholders and in fact very similar to the suggestion by Consultant #2 above. In an attempt to keep the number of water bodies low, which was in part a reaction to the first loop of consultations where concerns about an increase in water bodies' number were raised repetitively, additional WBs had not been delineated because of the existence of protected area boundaries only; however, WBs were delineated where the protected area boundary coincided with a change in the pressure situation. In addition, a look at the reality in the concerned catchments shows that the issue is a marginal one, i.e. any alternative approach would change the WB delineation, as proposed by the present study, in very few cases only.

Concluding about the concerns mentioned above, the divergent views of the stakeholders could not be united and remain, but future conflicts are not expected. The subject of the stakeholders' concerns does not cause issues with the European Commission.

4.2.4.7 Denser vs. sparser WFD river network, protection and management of rivers under WFD vs. national law

With respect to the methodology applied for the selection of streams, tributaries and headwaters for the proposed WFD stream network (cf. chapter 3.1.2), the stakeholders had differing views whether the proposed stream network is too dense or too sparse. In response to the proposed removal of some very small streams (i.e. with catchment area < $10km^2$), concerns and support for a denser network were expressed in the first session:

> "But, the concern exists, if you remove some streams, smaller than $10km^2$, afterwards you may not be able to protect them" (Hydrologist #2, 1st session)

> "For example, up to now there are cases where an applicant wants to put concrete in the river and we [the WDD] do not agree because these would be important hydromorphological alterations that are not compliant with WFD" (Hydrologist #2, 1st session)

While the stakeholder quote above supports that a river, which is part of the WFD stream network, is better protected than streams that are not included in this network, another stakeholder disagreed and supported that the national law, which covers all registered streams including even very small watercourses, is sufficient to protect rivers:

> "No, with the national law you can prevent alterations..." (Hydrologist #1, 1st session)

It must be noted here that both “opponent” stakeholders deal with river management on an everyday basis, implementing the same laws in a very similar institutional framework. Therefore, there is no straightforward “workplace” explanation for their differing views and reasons may lie in differing personal values. The subsequent discussion examined which approach would be most beneficial and how different decisions would affect management; it was concluded that, at least partly, the different scopes of the European and national level should be acknowledged:

> “There are two different issues, there is the monitoring network for WFD, and the protection of streams based on the national legislation” (Senior Hydrologist #1, 1st session)

The question of whether a sparser or denser WFD stream network would be more beneficial sparked controversies in the fourth session too:

> “I think that there are many water bodies for a country without water, that is striking...” (Senior Environment Officer, 4th session)

Opposition from another stakeholder followed immediately:

> “No, no, it’s not like that!” (Hydrologist #3, 4th session)

As can be expected from the above description, the differing views could not be consolidated into a mutually agreed consent and the conflicting views about the topic remained.

On analysis of the above deliberations and positions, I considered my proposal to be midway between suggestions for both a denser and a sparser network, and I consequently chose to maintain the proposal unchanged. The different views of the stakeholders remain but future conflicts are not expected once the final stream network will be adopted. The matter does not cause issues with the European Commission because the DProf proposal is based on a consistent, documented and well justified methodology.

4.2.4.8 E-type (ephemeral/episodic) streams in the Cyprus WFD stream network

In the first three sessions, the situation in ephemeral rivers had been recognized to be, on one hand, challenging with respect to monitoring (sampling, representativeness of results) and current data gaps, while, on the other hand, it became clear that these rivers are exposed to high pressure levels because they are mostly located in the lowlands within significant agricultural areas, industries and large agglomerations. In addition, ephemeral/episodic streams constitute the most frequent river type of the delineated water bodies (76 out of 230 i.e. 33%, cf. chapter 4.1.4).

In the fourth session, the question was raised whether water bodies of ephemeral/episodic type should be retained or removed from the stream network:

> "... the question is, if we need to leave these ephemeral streams as water bodies or not, I think it is very important that we look at that because it means cost, time, and many other things, I think there may be justification so they can be removed" (Senior Environment Officer, 4th session)

The above deliberation split the stakeholders' opinion. First, a WDD officer supported the position but immediately afterwards concerns about it were expressed, interestingly by a colleague of the participant "Senior Environment Officer":

> "But in the ephemeral rivers, what we observe very intensely, are the encroachments, hydromorphological pressures and various threats." (Environment Officer #2, 4th session)

The stakeholder refers to the high pressure level exerted at these rivers and considers that they would be better protected if they were WFD water bodies. This latter deliberation in turn was supported by several other WDD officers and the two "fronts" went on to discuss without reaching a mutually agreed conclusion. During the discussion, the protection of potentially removed water bodies or streams emerged as a theme (cf. chapter 4.2.4.7) and in parallel, the theme of potential reduction in monitoring by removing these streams weaved into the discussion (cf. chapter 4.2.4.4). I pointed out again that I consider the strict application of the quantitative $10km^2$ criterion for stream identification to be crucial for avoiding any risk of opposition of the European Commission, even more so as the DProf proposal already includes the removal of 25 entire river catchments (very small streams) and 42 tributaries. Several alternative ideas were put forward that were entangling the issue of water body identification with various approaches like taking into account pressures as identification criterion or joining water bodies of different type into one, which are all not compliant with WFD regulations.

An interesting finding is that the issue of retaining vs. removing ephemeral/episodic water bodies from the stream network split opinions in both Departments that deliberated on the topic, i.e. the WDD and the Department of the Environment, and the "opposed groups" were the same as the ones revealed in chapters 4.2.4.4 and 4.2.4.7.

The above conflicting views did not convince me to consider an adjustment of my proposal, for similar reasons as were already described in chapter 4.2.4.4. As a responsible WDD officer and researcher, I considered the risk of entailing future opposition or at worst the rejection of the proposal by the European Commission to become unacceptably large if I would abandon the quantitative $10km^2$ criterion for stream identification and remove water bodies and streams based on their stream type.

Concluding on the concerns mentioned above, the different views of the stakeholders remain but future conflicts are not expected once the proposed final stream network will be adopted. The matter does not cause issues with the European Commission because the DProf proposal is based on a documented and well justified methodology.

Further discussion of the issue of ephemeral/episodic rivers under the WFD is given in Appendix 17.

4.2.5 Feedback from the stakeholder consultation into the DProf proposal

While the consultation sessions did not reveal issues with a high chance to entail negative effects in practice, the discussions nevertheless raised my awareness for several matters that would need e.g. further justification or better and more detailed explanations in the project report. In addition, I have no doubt that the general atmosphere and opinions expressed by the stakeholders influenced my further decisions, both knowingly and subconsciously.

One such issue is definitely the position that was expressed by very few but adamant and “loud” stakeholders who pushed at every opportunity for the removal respectively reduction of streams and water bodies from the network that would be proposed in the end. This constantly raised issue undoubtedly impacted on me. For example, I became reluctant to split water bodies at boundaries of protected areas (cf. chapter 4.2.4.6) except in very clearly indicated cases or I did not delineate short river reaches with perennial flow as separate water bodies, e.g. on Diarizos river near Kidasi.

There were also few feedback topics that I revealed after the sessions only, while reflecting over certain stakeholder deliberations and writing the session memos. These issues were afterwards addressed; they fed back into the DProf proposal and are incorporated in the present project report, mainly in Chapter 3 and in the present Chapter 4.

These issues are:

- Identification of WFD water bodies in flood risk areas according to the E.U. Floods Directive 2007/60/EC; the approach to be applied in the present study was agreed during consultation session #1
- The need for clarification that the stream flow data used for the establishment of the river typology covers all flow regime types. I recognized this issue after the first session upon reflection about a stakeholder’s comment

- The need for clear explanations how rivers in those areas of the Republic of Cyprus, in which the Government of the Republic of Cyprus does not exercise effective control, were treated in this study (3rd session)
- The need to justify the selection of time series of 20 years for the establishment of the river typology (2nd session)
- The need to include information on the percentage of the proposed water bodies that have 1-to-1, 1-to-2, etc. correspondences with water bodies of the first RBMP (2nd session)
- The need for further justification with respect to the validity of the Cyprus intercalibration results for the proposed new river types, with the main addressee being the European Commission (2nd session)
- The need to provide more details on the assessment groups and in particular that not all stations in a group must have the same status; they must have the same pressure level, but status may vary and outliers can occur (3rd session)
- The need to provide a clearer and more comprehensive description of the methodology and procedure for setting water body codes (3rd session)

4.2.6 Discussion

During the two loops of the consultation process, I increasingly realized that the interrelationships and dependencies between the technical components are truly complicated, and it also became clearer and clearer to me that imagining the impacts of potential changes to these components is a very difficult endeavour for a stakeholder. As the project progressed, its results largely confirmed the findings from the literature regarding stakeholder participation in WFD implementation, which stress the difficulty and the large efforts (De Stefano, 2010, Reed, 2008) and the long time (Hernández-Mora and Ballester, 2011, Mostert et al., 2007, Irvine and O'Brien, 2009) needed to achieve involvement of stakeholders in complex technical issues. In that respect it is important to keep in mind that these papers describe public consultation processes while the DProf project deals with stakeholders who are supposed to be much closer to the issues under consultation. Given the tight deadline of the project, I realized that the expected active involvement of the stakeholders and their awaited useful deliberations and input in the development of the DProf proposal would not materialize but to a very limited extent only. Still, the first objective of the stakeholder consultation, i.e. to collect information about potential benefits and negative effects, was achieved.

From the early consultation sessions it was apparent that the main issue causing disagreement and discussion was the question which rivers and tributaries are delineated as WFD water bodies and which not, i.e. topics related to the review of the river network and its “ideal” density. Topics related to the other components of the DProf project like the river typology, its mapping onto the river network, the assessment groups scheme etc. received considerably less attention and there was no insistence from the participants on these topics, as it had been observed in relation to the review of the river network. One reason for this may be the different degree of technical difficulty between the quite technical topics of e.g. the typology and the rather crude question of delineating or not a river reach as WFD water body, which is of a much simpler nature and easy to grasp.

Concluding, the stakeholder process as it was implemented shows that initially, a wider consultation was envisaged but the first contacts with the stakeholders showed that the DProf topics were too technical and specific for them to be able to make substantial contributions. It must also be considered that for a stakeholder without knowledge of WFD details (e.g. the relation typology-monitoring-classification), the relations between the various components and repercussions between them must seem “horrendously complicated” as it was described by Smith et al. (2013). Thinking further ahead, it is clear that it is even more complicated and difficult to contribute and provide feedback while suggesting alternative approaches requires more knowledge still. Because of the above situation, contributions were few. Nevertheless, feedback was received for some DProf project topics and this was incorporated into the technical proposal; these instances refer mainly to improved explanation and description of specific issues.

The very limited contribution of the stakeholders and their apparent difficulties with the technical subject correspond to the finding of Howarth (2009) who had analyzed highly technical questions and methodologies in public participation processes under the WFD and who had reported that these are likely to exclude public engagement and to marginalise participants from outside a narrow community of expert stakeholders. In that sense, the present study largely “excluded” even institutional stakeholders from effective engagement, and environmental organizations, local Authorities (Municipalities, communities) and the public did not refer to the issues of the study at all when given the chance in the fifth session. However, lack of interest may have played a role too; in addition I believe that the stakeholders certainly, to some extent, had problems in developing opinions (Benson et al., 2014) and, at times at least, felt “too busy trying to understand the information to truly deliberate” (Blackstock et al., 2012, p.118). In the above sense, the DProf project confirmed the conclusion of Howarth (2009, p.406) that "as the issues become more specific and specialised, the pool of potential participants becomes progressively smaller".

The pool of potential participants in Cyprus for consultations regarding technical WFD topics, like the DProf project, corresponds to the relevant level of handling environmental issues in the sense of the "Rio Declaration of 27 principles of sustainable development" (United Nations Conference on Environment and Development, 1992). The findings of the DProf project suggest that this "relevant level" comprises only a very small circle of Governmental Departments. Further reflection leads to the conclusion that the group with real know how about the technical WFD topics of the DProf project may, in Cyprus, be not larger than a handful of people.

The limited extent of contributions of the stakeholders is at least partly due to limited capacity of the participants in the sense of De Stefano (2010) who characterized this as a major impediment for effective stakeholder participation. Upon reflection, however, it is probably unrealistic to expect a substantial group of knowledgeable stakeholders for technical topics like the DProf project in a small country like Cyprus without research institutes or University faculties that deal with related subjects.

The finding that the representatives of environmental organizations, of the Union of Communities and of some Municipalities made statements and asked questions at the fifth consultation session, but none of these questions were related to the topics of the DProf proposal, could be related to a scale issue. While the discussions in the fifth consultation session were on island-wide level, I think that for improved contribution, at least to the maximum extent possible for the technically complex matters, the issues would have to be discussed at a much more local level. If, for example, discussions about stream identification, stream typology and especially the relation of status to pressures would be discussed at the level of communities neighbouring the stream, it seems likely that local stakeholders would have the real picture of the specific watercourse in mind and would be able to relate its type to their personal experiences of e.g. the varying river flow throughout the year. In the same sense, they could relate the stream's pressure level to their own activities in its catchment.

An approach as described above is much more likely to provoke their deliberations than the discussion on national level based on island-wide maps of the identified stream network showing at one time river types and at another time the three pressure levels. The addition of such a local level approach would correspond to an improved "trade-off between a strong central government ... and a multi-level structure ensuring the best fit of each RBMP" (Nielsen et al., 2013, p.442), where the multi-level structure should always reach the crucial local level. The outreach right to the local level, i.e. to the people really impacted by measures may well trigger their participation, once they understand that they are being affected (cf. van der Heijden and ten Heuvelhof, 2012, p.10, van der Heijden et al., 2013, p.10). Such an approach may also allow revealing the true concerns but also the willingness to cooperate of e.g. local farmers or villagers, while stakeholder organizations (e.g. agricultural organizations) may pursue (at least slightly) different interests than the local people they represent e.g. farmers themselves. While it is clear that the local level could not be reached in the framework of the DProf project, I certainly acknowledge that the costs and resources required for setting up and maintaining such a system on an institutional basis may well be considered prohibitive by decision makers.

With respect to the advantages of the selected group context of the consultation, the sessions have allowed to reveal the divergence of opinions as well as the range of the participant's views (Robson, 2002), in particular with respect to the topics related to the review of the river network. Concluding, the likelihood that views outside the identified range will arise in the future is considered small. Still, a small chance of e.g. emerging dissent remains as it is well known that the absence of dissenting voices in group interviews or focus groups cannot be interpreted to indicate consensus (Robson, 2002).

Concerning the interrelations between the elaboration of the technical DProf proposal and the stakeholder consultation process, the findings of Nielsen et al. (2013) with respect to WFD implementation in six countries present some interesting similarities with the present study. They have found relations between the procedural focus on implementation deadlines and the focus on the more substantive objective of achieving integrated water management through participation processes, and they found that in order to achieve deadlines, "countries … have taken to central steering rather than multi-level integration" (Nielsen et al., 2013, p.445). An explanation for this may be that questions like "who participates and who not?" or "which mechanisms should be used?" are not specified in the Directive (Papadopoulos & Warin, 2007, in Pares, 2011), and thus the Member States can organize the participation of stakeholders in their own way (Liefferink et al., 2011). In contrast, the Directive "builds a very consistent frame in supporting the ecological visions to be promoted" (Steyaert and Ollivier, 2007, p.12), i.e. for the technical issues related to water body characterization, status assessment etc. This discrepancy in the description detail of the requirements subsequently leads to an imbalance of resource assignment. To some extent, I felt this dilemma too; my experience from developing the "new system", i.e. the technical proposal, while at the same time implementing the stakeholder consultation and handling the interrelations between the two, shows that the pressure to deliver a complex product in time may have tempted me to take decisions on my own and disregard potentially useful inputs from stakeholders. However, in the case of the present study, there was no compellingly useful input while the little valuable feedback that has been received was incorporated in the report. Still, the above comparison confirms the perception I have gained that the DProf project, by encompassing both highly technical issues and contacts with stakeholders, resembles a “miniature edition” of the entire WFD process.

With respect to the rather limited feedback from the stakeholders during the two action research (AR) cycles of the consultation process, it has some merit to reflect in a general way about what happens to an action research approach when stakeholders just accept the proposed change intervention. Without much contemplation it becomes apparent that insufficient input from the stakeholders deprives the planned AR application of its cyclical nature: improving the initially proposed intervention, based on stakeholder input of the first loop and, subsequently, in a second loop, returning to the stakeholders with the improved intervention proposal to seek further feedback just becomes unnecessary. Such a development means that the planned action research application loses a key characteristic of AR and may look like a “simple” change intervention. It becomes clear that the contribution of the stakeholders is a crucial and decisive factor that determines whether the planned action research methodology can be implemented as AR or it resembles, in the end, a change intervention without cyclical improvement process.

However, developing the above thoughts further, the next question that comes to mind is “Why would there be no feedback?”; and, following immediately “Why was the risk of the stakeholders’ failing to contribute not foreseen in the project planning phase?”. While the former question was discussed further above in this chapter with respect to the DProf project, the latter remains yet to be examined. It seems reasonable to accept that a researcher can never entirely foresee stakeholders’ reaction and feedback beforehand. Consequently, when starting an AR process, some “risk” always remains that stakeholder contribution turns out to be very little or lacks totally and that the initially proposed intervention may be accepted without dissent. Such a development then renders the process to look a lot like a “simple” change intervention as described in the previous paragraph above. Looking at AR from the above perspective, it becomes apparent that the appropriateness of implementing an AR process can hardly be fully assessed before putting it into practice; whether the cyclical AR process materializes does not become clear before the process is implemented in real-time and the contributions of the stakeholders emerge or do not emerge.

Nonetheless, in a real-life situation, it is unlikely that stakeholder contribution will be totally absent in a stakeholder process. This assumption held true for the DProf project where contribution was very little but existed; it did just not lead to amending the initial proposal. I was well aware that this development meant that the applied AR was being deprived of one of its key characteristcs, but I accepted it as it was a result of the dynamic development of the project. I resisted implementing unnecessary changes just to satisfy the completeness of the AR methodology, which could have been justified without much difficulty but would have counteracted the researcher's values. At this point, without hesitation, I decided to act as a responsible civil servant and practitioner, even though I knew that this decision might affect my position as a DProf candidate because justification of the applied AR methodology would become compromised to some extent.

Based on the explanations above, one could say that instead of an action research methodology, a "simple" consultation process would have achieved the same results. While this argument may well be true, the real question that remains in the end is whether or not one can still interpret the implemented DProf methodology as action research or not. Taking into account that, in the literature, AR is used as a term for a great variety of approaches (Eden and Huxham, 2002) without a unifying methodology (Gill and Johnson, 2002), it is in the end the decision how narrow one sets the boundaries of what he considers AR that determines whether or not the implemented DProf methodology would be interpreted as AR or not. Having carried out this work, I consider the feedback received and the improvements to the DProf report brought about by it sufficient to consider the implemented methodology to be action research.

The cyclical nature of the action research approach brought about repeated exposure of the participants to the project's topics and this in turn allowed the participants to gradually restructure their view on the proposal, in the sense of Gill and Johnson (2002). The sessions being held in AR loops resemble "reconvened groups" in the sense of Finch and Lewis (2003, p.172) who described them as a variation of focus groups. The latter authors found reconvened groups to be valuable when issues are intangible or unfamiliar to respondents and the intervening period provides an opportunity for participants to reflect and become more familiar with the topics. This was to some extent confirmed by the present study as the cyclical process of reconvention and re-iteration helped the participants to gradually consolidate their picture of the issues under consultation, without however significant or specific impact on the outcome of the study. The reconvened groups of Finch and Lewis (2003) can be seen as a link between focus groups concepts and action research that is established by introducing a repeated or cyclical reconvention of the groups.

When assessing the DProf's consultation process it is important to note that, while the technical nature of the DProf made it difficult for the stakeholders to understand and to contribute, it would be wrong to conclude that they did not deliberate because they did not understand at all the issues being consulted upon. The stakeholders recognized the improvements brought about by the proposed intervention and they expressed their satisfaction with the proposal, thus clearly indicating that they understood enough to arrive at these conclusions. Thus, they understood enough to judge whether to agree or to disagree with the proposal but they did not consider it "necessary" to request amending the proposal.

Reflecting about my failure to correctly assess the risk that stakeholder feedback may not emerge during the project planning phase, I realized that, perhaps, because of my own deep involvement in the DProf issues over several years, I may have developed the personal misconception that my colleagues are much more knowledgeable and interested in the DProf project topics than they turned out to be in reality. Such misconception may have developed from an overestimation of the DProf issues' importance because I was myself working very intensely and continuously, at times exclusively, with these issues.

During the consultation process, no feedback was received that compellingly indicated the need for amending the initial proposal. This is considered to be, at least partly, due to the fact that I had in the past been so deeply involved in the process to be changed; I was not an external consultant imposing change without sufficient insider knowledge. Consequently, the proposal emerged right from the epicentre where the DProf issues are dealt with in everyday practice in Cyprus and where they would be dealt with in the future too. Therefore, I had a high interest to propose a sound and working system – I would not "walk away" after implementing the change but would have to deal with it in my everyday professional life. It is certainly acknowledged that too deep involvement may often prevent "thinking outside the box" and block the view for truly innovative solutions. I can hardly judge myself whether this was the case in the DProf project. However, even if someone considers the implementation of AR in the DProf as "incomplete", it remains clear that this "incompleteness" had not impacted in any negative way on the outcome of the project – the set objectives were met if not exceeded, and the project's outcomes were well received by the stakeholders.

The success of the implemented "virtual action research methodology" was found to depend on the degree of technical difficulty of the subjects. While the stakeholders deliberated to a satisfactory extent upon easier subjects such as the review of the river network, more difficult subjects (such as the river typology or its mapping onto the river network) saw much less deliberation; a full, non-virtual, application of AR, i.e. implementing the proposal in practice, would probably have revealed impacts more obviously and perhaps caused more reaction from the stakeholders. Still, as it was explained in chapter 3.2, such an implementation was impossible in the framework of the DProf project. However, the partial implementation of the DProf proposal, which was presented in the fourth stakeholder session and led to good comprehension of the specific DProf components by the stakeholders, indicates the advantage of practically implemented interventions over virtually explained changes and impacts. Therefore, I consider the “virtual action research methodology” as applicable only in cases where the virtual approach can achieve full comprehension of the proposed change and full anticipation of its impacts by the participants, and the approach is rather unsuitable for subjects of great technical difficulty or complexity.

The dissent within the Water Development Department about the inclusion or exclusion of river reaches as water bodies becomes understandable, and one is tempted to say that it is even “built into” the Department, by considering its double role. The Integrated Water Management Law 79(I)/2010, which is the legal basis for most of the activities of the WDD, stipulates the mission of the Department in Art. 3(2):

> “The mission of the Water Development Department is the development, protection and management of the water resources and the safeguarding of the sustainability of these resources within the framework of the Government water policy”

Through the above mission definition the double role of the Department with respect to both development and protection of water resources is prescribed by law and, consequently, corresponding conflicts are to be expected within the Department. For example, one division of WDD is responsible for the protection of streams and their riparian zones and in streams that fall under the WFD, protection is easier to enforce (cf. e.g. Acuña et al., 2014); however, at the same time another division of WDD may be instructed to realize e.g. a storage reservoir (“development”) and if the proposed location is situated on a stream that falls under the WFD, i.e. the stream is a WFD water body, then the procedure for environmental permitting as foreseen by the WFD (e.g. Art. 4.7 WFD) must be followed. This entails more work and the need for a stronger justification than a standard environmental impact assessment procedure. As a result, while one “part” of the WDD would prefer to include streams as WFD water bodies to enforce protection, another “part” of the Department would prefer to delineate as less as possible water bodies to avoid obstacles for water development works to go ahead. Thus the tensions within WDD become somewhat understandable due to the double mission of both protecting and developing Cyprus’ water resources.

With respect to the cases where different views persisted between the stakeholders, the proposal was found to be midway between the opposed fronts and thus it was not amended due to findings from the consultation process; in fact, the dissent between stakeholders with positions on either side of the DProf proposal actually indicates that the proposal is rather well balanced.

The stakeholders had recognized that the DProf proposal for the "review and update according to Art.5 of the WFD" refers to the second Cyprus RBMP and that the next review is due in six years for the third RBMP. In retrospect it seems very likely that the stakeholders' recognition of this fact has influenced their position towards the proposal, as it became clear that there will be a chance to "correct" or "adjust" the scheme in a few years time. This outlook leaves any related decision appear less ultimate and puts the consequences of embracing or rejecting the proposal into their real-life framework.

The above reasoning exhibits an analogy between the DProf project and the implementation cycles of the WFD. In fact, both apply action research principles, i.e. they implement changes in loops with intermediate phases of evaluation and re-adjustments of the implemented measures. The present study could not implement the proposed changes in reality and therefore had to resort to "virtual action research"; still, the proposed changes will, in case they are finally adopted, be implemented in reality and will be evaluated in the next action research loop of WFD implementation, i.e. the consultation process for the third RBMP.

From the quantitative analysis of the stakeholder consultations it is clear that the WDD Contractor's participants contributed an important number of deliberations (Figure 18). The qualitative analyses showed these deliberations' aptness, technical knowledge and pertinence to the issues under discussion (chapters 4.2.3 and 4.2.4), features that were not always characteristic of the deliberations from Governmental stakeholders (cf. e.g. chapter 4.2.4.8). This shows that consultants who carry out Governmental contracts have much expertise while this expertise seems to be lacking, at least partly, amongst Governmental stakeholders. This leads to the question how such expertise is incorporated and enhanced over time in responsible Governmental organizations, in the light of obviously changing consultants from one contract to the next. The findings indicate that there is, at least to some extent, an imbalance towards the outsourcing of work that leads to lack of specific knowledge at the contracting authorities or to the concentration of such knowledge on very few Government officers only. The latter are, in turn, on their own with their specific knowledge without the opportunity to scrutinize, challenge and develop it further in discussions with colleagues.

4.3 Recommendation of the DProf proposal as well as the potential effects of its implementation, to the Director of the Water Development Department.

The findings below correspond to the DProf project's Objective 5: To present and recommend the new spatial basis of rivers monitoring and management for the implementation of the E.U. Water Framework Directive in Cyprus, as well as the potential effects of its implementation, to the Director of the Water Development Department, for adoption.

For achievement of the above objective I submitted a corresponding report to the Acting Director[8] of the Water Development Department, in January 2016. The report includes descriptions of all the technical work as well as descriptions of the methodology and the results of the stakeholder consultation, and includes as main recommendation the adoption of the technical proposal elaborated by the DProf project and the acknowledgement of the related benefits and potential negative effects, for future WFD implementation and river management in general.

The Acting Director responded with a very positive letter addressed to me, which is presented in Appendix 18.

4.4 Project outcome, products and their utilization

At the time of writing, the results of the present study have already been used and implemented as described in the following chapters.

4.4.1 <u>Contract YY02/2013</u>

The proposed river water body network, which incorporates the proposed river typology, and the assessment groups scheme (cf. chapters 4.1.4 and 4.1.6) have been used as the basis for contract YY02/2013 for the "Review and update of article 5 of Directive 2000/60/EC (water reservoirs) & classification of water status (rivers, natural lakes and water reservoirs), that will establish baseline information and data for the second Cyprus river basin management plan", as far as rivers are concerned. The related report is available from the website of the WDD:

http://www.moa.gov.cy/moa/wdd/wdd.nsf/all/AAA019E372936A76C2257E6500271FB4/$file/Ekthesi_art5_Tax_river_dams.pdf?openelement

It is worth noting that the above contract accomplished the determination of the ecological status of all river water bodies, while in the first RBMP 24.5% of all river water bodies could not be classified and had "unknown" ecological status (Karavokyris & Partners Consulting Engineers S.A. and Kaimaki, 2009).

I contributed chapters 5.1.1 and 5.1.3 to the report, while the water bodies proposed by the DProf project are shown (identifiable by codes, names) with various related water status results in various tables throughout the report, and they are also the spatial basis (in digital GIS format) of the respective maps included in the report.

[8] Note: The Acting Director has been the Head of the Department since the retirement of the previous Director, as no vacant posts are being filled in the Civil Service because of the Cyprus financial situation (economic crisis).

4.4.2 Contract YP01/2014

The river water body network, which incorporates the proposed river typology, which is proposed by this study, was also used as basis, as far as rivers are concerned, for contract YP01/2014 with respect to the "Review of the impact of human activity on the status of surface waters" according to Article 5 of the WFD. This report is also available (in Greek with a summary in English) on the website of the WDD:

http://www.moa.gov.cy/moa/wdd/wdd.nsf/all/F2F8C6373178B8D3C2257B5700385340/$file/Epikeropoiisi_Article_5_2014.pdf?openelement

In the report, the water bodies proposed by this study are shown (identifiable by codes, names) with various related pressure data indicating the "impact of human activity" on them. In addition, they are the spatial basis (in digital GIS format) of various maps shown in the report while the catchments of the water bodies, as polygons in digital GIS format as they were elaborated within the present study, have been used by contract YP01/2014 to collect and organize the information about the "impact of human activity" on the water bodies.

I contributed Appendix B to the report of contract YP01/2014, which is an application of the methodology for the elaboration of the assessment groups scheme that has been developed in the present study (cf. chapter 3.1.7) but using real pollution loads, which had been established by contract YP01/2014, instead of the proxy pressure data that have been utilized in the present study. The results in Appendix B of the report of contract YP01/2014 confirm the results found in this study (cf. chapters 3.1.7 and 4.1.6) and demonstrate the usefulness and suitability of the methodology developed in this study.

4.4.3 WFD river monitoring scheme

The monitoring network and schedule has been completely revised by the WDD using the water body network, which incorporates the proposed river typology, and the assessment groups scheme as proposed by this study. The DProf proposal allowed for the structured formulation of a much more targeted WFD monitoring schedule, as compared to the past, for the entire third monitoring cycle of the Directive, i.e. from 2015 to 2019. The revised monitoring network and schedule are already being implemented since January 2015. Because the pressure levels of the water bodies were established by this study and are known, monitoring stations could be placed to cover the whole pressure gradient for each river type. This will allow, by end-2019, both checking and improving the assessment groups scheme for the accurate and reliable prediction of the water status of all river water bodies for the third RBMP; improvements are expected in particular in river types where data gaps have been identified in this study, namely in river types Ih and E.

As evidence, the Memorandum of Understanding 2015 between the WDD and the State General Laboratory of Cyprus (SGL) for the analyses to be undertaken by SGL for WDD (in Greek) is included in Appendix 19. Such a memorandum is prepared and signed every year, and the river water bodies (identifiable by codes, names) as well as the assessment groups proposed by this study are shown in Table A2 of the memorandum.

In my personal view, the establishment of the rivers monitoring programme for the third RBMP somehow “closes the circle” of the DProf proposal, as this is the outcome that really improves river quality monitoring, because the WDD can now target monitoring efforts much better. The Department is now in a position where it no longer removes and adds monitoring stations from year to year without much of an overall plan - now there is an established plan for collecting data according to a set schedule during 2015-2019. The fact that this is a medium-term plan greatly improves resources planning for the years to come. Nevertheless, the programme will need adjustment from year to year based on experiences gained from the very programme. In fact, changes are already arranged for the 2016 monitoring programme, based on stream types and assessment groups as established by the DProf project, indicating the value of the DProf outcome and its implementation in every day rivers management.

4.4.4 Water Development Department’s Geodatabase

The water body network proposed by this study (cf. Figure 14 and chapter 4.1.4) has been made available to all the Department’s GIS users in the Department’s Geodatabase, in digital vector GIS format (polylines) and with complete metadata description. The metadata are presented in Appendix 20. The Geodatabase is only accessible in WDD premises.

The catchments of the water bodies (245 polygons) as well as the catchments of the 60 streams of the proposed stream network (60 polygons) are also available in vector GIS format, supplementing the water body network.

A number of raster data sets, congruent with the vector data set of the water body network, are also available and provide additional information about the stream network, e.g. a flow accumulation grid (showing the catchment area for every grid point), a flow length grid and a flow direction grid.

4.4.5 Elaboration of the 2nd Cyprus River Basin Management Plan

The river water body network, which incorporates the proposed river typology, which is proposed by this study, is currently being used as basis for the elaboration of the second Cyprus River Basin Management Plan. Related material is available (in Greek with executive summaries in English) on the webpage of the WDD:

4.4.6 Geospatial Information Portal of Cyprus

The river water body network proposed by this study (cf. Figure 14 and chapter 4.1.4) is available to the public in the “Geocatalog” of the “Geospatial Information Portal of Cyprus” as a geospatial data layer authored by the Water Development Department, i.e. my workplace. The “Geocatalog” is available at the following URL:

http://213.136.80.55:58086/geonetwork/srv/eng/catalog.search#/home

At this internet site, the network of river water bodies the river water body network can be found under the name “River Water Bodies (Water Framework Directive)” in the INSPIRE Categories/Topics “Hydrography” and in the ISO19139 Categories/Topics “Inland waters”, or it can be found using the term “river water bodies” in the search function. It can then be viewed on a map and overlaid with other geospatial information, and it can also be downloaded for further use in GIS software by any interested individual or organization, including the complete attribute information of each water body (code, name, river type, etc).

The above is an example of wide dissemination of the outcome of the DProf project, as a main outcome of the project is made available to the public for free download.

Chapter 5. Conclusions and recommendations

The main conclusions from the DProf project as well as recommendations that emerge from them are described in the following chapters.

5.1 Conclusions

The purpose of the conclusions are to "demonstrate how the background theory and the focal theory are now different as a result of the study" (Phillips and Pugh, 2005, p.60); in the case of this study this is interpreted as a demonstration how the results and the outcome of this study have impacted on the local level, i.e. WFD implementation and river management more generally in Cyprus, and what the study contributes to "background and focal theory", i.e. to academic knowledge in the fields pertinent to the study's subject.

5.1.1 Technical part of the DProf project

Review of the river network

A new WFD stream network was created by applying consistent quantitative criteria for stream delineation and following the size criteria suggested by the WFD. Compared to the stream network of the first RBMP (WL | Delft Hydraulics et al., 2004), six streams were added while 25 streams were removed and this process yielded 60 streams to become the proposed new WFD stream network. The total catchment area of the proposed stream network, in comparison to 2004, increased slightly from 6507.1km^2 to 6529.2km^2. The total length of the stream network decreased slightly from 2637.5km in 2004 to 2623.1km in the present study. While these quantitative characteristics of the stream network changed only slightly in comparison to 2004, the improvement lies in the fact that it is a sizewise consistent stream network: It is strictly based on the area threshold for small catchments of 10km^2, which has been used widely also by other E.U. Member States, as well as on documented and consistently applied criteria for the selection of tributaries and headwater streams to be included in the network.

Another advantage of the new stream network over the one of 2004 is the fact that its digital (GIS) version is supplemented by a number of raster data sets, e.g. a flow accumulation grid showing the catchment area for every grid point, which will ease everyday river management.

Elaboration of the new river typology

This refers to research objective 1 of the DProf project "To elaborate a new typology for Cyprus rivers".

A new river typology was elaborated based on the hydrological regime according to the TSR method of Gallart et al. (2012). The four proposed river types cover the entire gradient of flow regimes from perennial to ephemeral/episodic. Each proposed type is directly related to the applicability of biological monitoring for WFD purposes and this provides justification to use, or not to use in the case of stream type E, biological quality elements for the assessment of status. In addition, each proposed type is described by a number of hydrological characteristics, amongst others the expected typical length of its flow period and the river flow's predictability. These parameters will facilitate more targeted and more efficient monitoring scheduling in the future and, in a general sense, contribute to a better understanding of the variety and variability of rivers on the island and subsequently improved management of the island's lotic waters.

As far as I have found out, this research is the first to apply the Temporary Stream Regime (TSR) typology system proposed by Gallart et al. (2012) for the elaboration of a national river typology for the purpose of WFD implementation. The method performed well in the present study in Cyprus and I consider it to be a suitable method for the elaboration of river typologies in areas of predominantly temporary rivers; the use of rather simple methods using very few parameters for temporary rivers classification is also supported by the recent work of Snelder et al. (2013) on French intermittent streams. Still, it is clear that the method does not provide differentiation of perennial river types and this might be a serious limitation in more temperate areas.

The TSR method was found to be applicable even without continuous streamflow records, i.e. monthly spot measurements of stream flow are sufficient to calculate the two metrics of the TSR method. In contrast, the majority, if not all, other documented methods of determination of flow regimes e.g. the IHA parameters (Richter et al., 1996) require continuous streamflow records. While an application based on monthly spot measurements may give slightly cruder results compared to using continuous streamflow data, I found the results absolutely sufficient for the purpose of this study. The benefit of being able to use regular spot measurements is considered significant because it allows determining the TSR without installing flow gauges, while even historic series of spot measurements may be used.

This research is also the first, as far as I have found out, to compare stream type classifications of the TSR method to results from a cluster analysis that was run on the same set of flow gauging records. The outcomes of the two methods were very similar while the few differences in classification occurred mostly amongst the two intermittent types I and Ih (I-P and I-D according to Gallart et al. (2012)). This study thus considers results of the TSR method equivalent to types derived from cluster analysis as far as the crucial distinction between perennial, intermittent and ephemeral/episodic stream regime is concerned.

A striking similarity of the Temporary Stream Regime Plot (TSR plot) created with the Cyprus stream flow records with the corresponding plots from Evrotas river in Greece by Cazemier et al. (2011) was found. The TSR plot may well proof to be valid as a general Mediterranean relationship, once data from more areas will become available.

For the first time, the different temporary flow regimes of Cyprus rivers were investigated in an island-wide study, after the application to one catchment by Tzoraki et al. (2014). Based on stream flow records, it was shown that Cyprus rivers cover the whole gradient of flow permanence from perennial to intermittent to ephemeral/episodic. Each flow regime type was characterized by its hydrologic characteristics and catchment characteristics. The latter makes a contribution to filling knowledge gaps in relation to temporary rivers that had been lamented in the literature (Larned et al., 2010, Tzoraki et al., 2007, Steward et al., 2012, Hughes, 2005, Jacobson and Jacobson, 2013).

<u>Mapping river types onto the river network</u>

For the mapping of the new proposed river types onto the new proposed stream network, a tiered approach was used that allowed taking into account the different data availability in the stream reaches. For those cases where flow data was not available, relationships between the new stream types and catchment characteristics were established and a multi-criteria methodology for assigning stream types to these ungauged stream reaches was developed. This process yielded a stream network comprising 184 typified river reaches, which corresponds to the Cyprus WFD river network under contemporary near-natural hydrological conditions.

With respect to network length, 14% has perennial flow, 27% is intermittent, 22% is harsh intermittent and 31% exhibits ephemeral/episodic flow regime; 6% of the network remained without river type due to lack of data, corresponding entirely to river reaches in those areas of the Republic of Cyprus in which the Government of the Republic of Cyprus does not exercise effective control. In comparison with the stream network that had been identified by WL | Delft Hydraulics et al. (2004), the total length of perennial rivers has increased from 11% to 14% of the total network length in this study, due to river reaches that were identified to have perennial flow in the present study; because these river reaches had been characterized to have a temporary flow regime before, the length of temporary rivers (types I, Ih and E) is reduced correspondingly from 89% to 86% in this study.

A comparison with shares of temporary rivers in entire stream networks elsewhere showed that the 86% temporary rivers found in Cyprus by this study is similar to states of the U.S. southwest e.g. Utah (79%) and New Mexico (88%) as reported by Levick et al. (2008); in addition, the character of Cyprus rivers compares well with streams in southwestern Arizona, again as reported by Levick et al. (2008), with respect to the upstream to downstream gradient of flow occurrence.

Acuña et al. (2014) had proposed policies for improved management of temporary waterways, and have concluded that improved mapping of temporary waterways is needed to implement these policies. In the same sense, Snelder et al. (2013) pointed out that predictions of regional patterns in flow intermittence provide useful information for applications including environmental flow setting, estimating assimilative capacity for contaminants, designing bio-monitoring programs. This study, by mapping the different types of temporary streams on an island wide basis, makes a contribution towards achieving these policies' implementation while in parallel it provides useful information for the applications mentioned by Snelder et al. (2013), in Cyprus.

The stream network map of near-natural flow types developed by this study constitutes the first mapping of temporary flow regimes onto a Cyprus-wide river network and may serve several purposes, apart from its role in WFD implementation. If the information it contains is utilized, it may improve management decisions that require information concerning the natural flow regime and can have practical use as a spatial framework for both river research and management purposes in the sense of Snelder et al. (2009). It can also provide a basis for the "preservation or restoration of natural flow regimes", which was proposed as one of three primary objectives for effective temporary river management by Larned et al. (2010, p.730) and also to "implement water resources policies and manage temporary rivers as networks" (Leigh et al., 2015, p.10). With respect to ephemeral rivers, their spatial extent has now been established and that allows e.g. investigating the ecological importance of their contributions to local and regional aquifer recharge and water quality (Boulton, 2014) but also to the ecosystems they support along their course. From the above it becomes clear that the outcome of the DProf project improves the basis for rivers management in Cyprus. With the mapped stream types, e.g. measures specific to perennial, intermittent or ephemeral rivers can be taken in a way that is adjusted to their flow regime characteristics, because their location and spatial extent is known. The knowledge about the variability of their flow characteristics along their entire course facilitates better informed decisions on the catchment scale and also about the impact of e.g. upstream alterations to the reaches further downstream.

Temporary river “mapping and predictive modeling of flow intermittency” was identified as one of several ‘hot topics’ of research by Leigh et al. (2015, p.10) that are essential to improve understanding and management of temporary rivers. They further state that improved mapping of temporary rivers and models for predicting flow permanence in temporary rivers are needed to, amongst others, implement water resources policies and manage temporary rivers as networks. The DProf project addresses these ‘hot topics’ through the development of a simple methodology that allows prediction of flow intermittency, i.e. temporary stream regimes, from catchment characteristics, which in turn facilitates the mapping of stream types to the ungauged reaches of the stream network. This methodology allows predicting the three major flow regimes perennial, intermittent and ephemeral/episodic flow. While it is clear that the thresholds are strictly applicable only in the area of study, i.e. Cyprus, it could well be calibrated with data for other areas. With respect to misclassifications, the method performs comparably with approaches reported by Kennard et al. (2008), Mackay et al. (2012) and Snelder et al. (2013).

Global estimates of the amount of ephemeral/intermittent streams are lacking (Raymond et al., 2013) and thus this study makes a contribution, even at the small scale of the island of Cyprus, by determining the share of temporary streams with respect to the entire stream network.

Water body delineation

This refers to research objective 2 of the DProf project “To delineate river water bodies based on the newly developed river typology and on pressures”

The typified river reaches were transformed into water bodies in the sense of the WFD by taking into account the location resp. the spatial extent of pressures, differences in water status, protected areas and HMWBs. The HMWBs of the first RMBP were adopted without change, except where streams had been split due to the new river typology. The outcome of this procedure is 245 river water bodies, comprising of 15 impounded river HMWBs, i.e. water reservoirs, and 230 genuine river water bodies. Compared to the river water body network of the first RBMP (WL | Delft Hydraulics et al., 2004) the number of water bodies increases by 6%.

The slight increase in the number of water bodies is thought to not entail increased monitoring efforts, which are expected to remain at the present level. However, as a whole, the new proposed system has already contributed significantly to improved monitoring results. It allowed for the determination of the ecological status of all river water bodies (cf. chapter

4.4.1), while in the first RBMP 24.5% of all river water bodies could not be classified and had "unknown" ecological status (Karavokyris & Partners Consulting Engineers S.A. and Kaimaki, 2009). It is thus evident that the increase in the number of water bodies is balanced by the improved adaptation of the new system to Cyprus conditions as well as by the enhanced efficiency and ease of scheduling that result from it; these facts had also been acknowledged by the stakeholders in the consultation sessions (cf. e.g. chapter 4.2.3.2). This progress, in comparison to the first RBMP, was made possible by the cumulative improvement of the new typology and its careful mapping onto the stream network, especially the considerate delineation of the water bodies with respect to the pressures and the newly established assessment groups scheme. The latter, of course, would not have been as successful as it proofed to be without the suitable typology and water body network established beforehand in the present study.

Another advantage of the new proposed water body network over the one of 2004 is the fact that its digital (GIS) version is accompanied by a GIS data set including the catchment polygons of all (polyline) water bodies. This GIS layer facilitates the rapid collection of data on water body level e.g. on pressures or physical catchment characteristics.

Elaboration of the water body coding scheme

A new coding system for the water bodies was elaborated and applied. The new coding system retains the historic Cyprus catchment codes (e.g. 1-1, 1-2, etc.) and includes river type, HMWB indication as well as "impounded river" indication, where appropriate, as part of the code for easy referencing, and it allows for meaningful sorting by the WB code in tables, data bases etc. The new proposed system is fully documented (cf. chapter 3.1.6) and allows for unmistakable distinction of the codes proposed in this study from the codes elaborated by WL | Delft Hydraulics et al. (2004) that had been used in the first RBMP. The new proposed system also avoids mix-ups of water body codes with the historic Cyprus subwatershed codes, which was not ensured with the coding system of 2004.

Elaboration of the water body grouping scheme

This refers to research objective 3 of the DProf project "To elaborate a grouping scheme of river water bodies"

An assessment groups scheme was elaborated and all water bodies were assigned to groups of similar pressure levels, while keeping the river types separate. To this end, water status data was related to pressure data and thresholds for negligible, minor and significant pressure levels were determined. This work culminated in the development of a "combined pressure indicator" (CPI) that allows the prediction of pressure levels and related ecological status of water bodies in the Cyprus water body network; this indicator was used for grouping the water bodies according to their pressure level. The procedure resulted in 12 assessment groups corresponding to negligible, minor and significant pressure level for each of the four river types. Upon practical implementation of the DProf project's proposal, these assessment groups enabled assessing water body ecological status of all WBs that are not being monitored. This constitutes significant progress over the situation in the first RBMP, when 24.5% of all river water bodies could not be classified and had "unknown" ecological status (Karavokyris & Partners Consulting Engineers S.A. and Kaimaki, 2009).

The assessment groups scheme elaborated by the present study responds to the need for tools to evaluate ecological status for water bodies for which no data are available that had been recognized by Reyjol et al. (2014) and thus made a contribution to reduce the knowledge gap and lack of tools for this specific research need. The "combined pressure indicator" development in this study, if adopted and used, has the capability to advise decision makers in Cyprus how to deal with combined pressures and thus addresses the lack of conceptual models hitherto that had been identified by Garcia and Wasson (2005). The methodology is strictly applicable only in the area of study, i.e. Cyprus, but it might in the sense of Munné and Prat (2004, p.712) be "exportable to other Mediterranean River Basin Districts or many parts of the world by changing variables according to the local features".

This study contributes to better understanding of the impact of pressures on the ecological status of temporary streams, a gap that had been identified by several writers in the pertinent literature (e.g. McDonough et al., 2011, Leigh et al., 2015) and that was also identified to lead to widespread degradation of temporary rivers (Acuña et al., 2014). Thresholds of three proxy pressures have been identified that correspond to the high/good and to the more crucial good/moderate status boundaries that represents the transition from insignificant to significant pressures in the sense of the WFD. While these thresholds were elaborated only to facilitate the establishment of the assessment groups scheme, they could serve as indications where management efforts for the achievement of good ecological status, the main environmental objective set by the WFD, should be focused. In so far, I have applied and confirmed the methodology applied in this study, including the thresholds, by using loads of N and P in the framework of a service contract where I contributed these calculations as an annex.

Leigh et al. (2015) in their review of research and management of intermittent rivers have identified a need, amongst others, for improved understanding and predictive capacity about how temporary rivers respond to anthropogenic stressors, including multiple stressors. The elaboration, in this study, of relations between the pressure levels and the ecological status and the estimation of thresholds of “significant pressures”, in the sense of the WFD, are a contribution towards this improved understanding, while the “combined pressure indicator” (CPI) developed in this study represents a simple approach to cope with multiple pressures.

5.1.2 Stakeholder consultation

This refers to research objective 4 of the DProf project “To collect information, from major stakeholders but also from other supporting sources, on anticipated benefits and potential negative effects of the proposed new river water bodies network”.

The stakeholder consultation was carried out in two action research loops with a total of five consultation sessions. The stakeholders present in the sessions included the Water Development Department as main stakeholder, all other significantly involved Government Departments, a WDD contractor as well as, in the last session, environmental organizations, local Authorities and the general public.

The general response of the stakeholders to the DProf proposal was that its adoption would bring about an improvement for river management under the WFD in Cyprus. The stakeholders acknowledged that the monitoring workload, as compared to the system of the first RBMP, will not be reduced but will stay approximately the same, while results will be more accurate, reliable and with better spatial coverage.

Specific benefits were identified; they are few but significant and refer to improved monitoring, the benefits of the new typology on the monitoring, gaps that were identified and can be addressed now in a targeted way, and the developed methodologies that can be re-applied in the future.

Some causes for potential negative effects of an adoption of the technical proposal were identified but none of them bears a high chance to entail negative effects in practice. A topic that bears a small chance of entailing negative reactions from the European Commission is related to the treatment of HMWBs in the assessment groups scheme in this theme, where the root of the problem however is the lack of an assessment method for the Good Ecological Potential (GEP) that is outside of the scope of the DProf project. A minimal chance of disagreement of the European Commission is considered to exist with respect to the compatibility of the new types with the results of the intercalibration exercise and the fact that the river network is completely new, in comparison to the first RBMP; the chance of opposition of the European Commission to the proposed removal of very small streams in protected areas is considered negligible.

Possibly more important than the potential negative effects, however, are the differing views amongst stakeholders about several areas of WFD implementation that were identified. They exist between the participants but also within Governmental Departments, e.g. the Water Development Department, and refer mainly to the “ideal” density of the stream network and the treatment of ephemeral/episodic rivers under the WFD. With respect to the divergent opinions whether delineation of a watercourse as a WFD water body or not has an influence on its protection, Acuña et al. (2014) hold that a temporary stream not considered a water body is not protected, thus supporting that delineation or not does make a difference for protection.

This study identified the stakeholders in Cyprus that can contribute to consultations regarding technical WFD topics like the DProf project to be only a very small circle of Governmental Departments including the Water Development Department, the Department of the Environment and the Department of Fisheries and Marine Research, while the group with real know how about the technical WFD topics of the DProf project may, in Cyprus, be not larger than a handful of people. The DProf project’s outcome also indicates that, in Cyprus, the specific issues of the DProf project are either too technical or of no interest for stakeholders outside of Governmental Organizations, i.e. environmental organizations, local Authorities and the general public.

The stakeholder consultation process has certainly raised awareness and knowledge amongst the participating stakeholders for topics like the exclusion or inclusion of rivers into the WFD river network, the river typology, the water body delineation and also water status assessment by application of the assessment groups scheme. In particular the extended discussions about retaining or removing ephemeral rivers from the WFD stream network undoubtedly led to memorizing the different types of temporary rivers, intermittent and ephemeral rivers at least, in the stakeholders’ minds. By achieving the above, the stakeholder consultation process of the DProf project has contributed to improved implementation of the WFD in Cyprus in the future, through increased pertinent knowledge amongst stakeholders. This contribution is especially important at the Water Development Department because it is the responsible authority for WFD implementation at the operational level in Cyprus.

The topics of the DProf project were very technical and specific and the stakeholders had difficulties to cope, they could not make substantial contributions to the technical proposal and were thus “excluded” from effective participation. This situation confirms the findings of a number of studies that investigated WFD consultation processes in other E.U. Member States and identified similar problems (Benson et al., 2014, Blackstock et al., 2012, De Stefano, 2010, Smith et al., 2013, Howarth, 2009).

The DProf study found indications that the degree of technical difficulty is related to the emergence, or not, of conflicts on specific issues. In technically rather simple subjects like the review of the river network, where the impact of delineation or not of a watercourse as WFD water body with respect to its protection respectively the implementation of water development works is easily anticipated by stakeholders, persistent controversies emerged that could not be resolved during the consultation process. In relation to technically more difficult subjects like the grouping of water bodies into groups of similar pressures for the assessment groups scheme, on the contrary, it seems that the rather vague anticipation of potential impact may have kept the participants from insisting on their positions and led them to agreement, probably out of an insufficiently precise idea of the consequences of the proposed scheme.

The degree of technical difficulty was also found to be important with respect to the "virtual action research methodology" applied in this study, i.e. AR without actual implementation of the change intervention. The stakeholders deliberated to a satisfactory extent about rather easy subjects, such as the review of the river network, but much less deliberation and discussion was recorded about more difficult subjects such as the river typology or its mapping onto the river network. Therefore, the "virtual action research methodology" is considered applicable only in cases where the virtual approach can achieve full comprehension of the proposed change and full anticipation of its impacts and the approach is rather unsuitable for subjects of great technical difficulty or complexity.

Concluding and looking back on the outcome, I have made contact with all major stakeholders in five events and the aim to collect the concerns of the stakeholders for the identification of potential negative effects was achieved. Input to the technical DProf proposal was scarce, which confirms the findings from the literature. The Water Development Department, by eventually adopting the DProf proposal, faces only minimal chances of negative effects from the European Commission, while the Department can be more or less sure that there will be no objections from national stakeholders.

5.1.3 General conclusions from the DProf project

The results of the present study have already been used and implemented:

- as the basis for the classification of river water status, for the implementation of the WFD, in the framework of a service contract
- as the basis for the review of the impact of human activity on the status of surface waters, for the implementation of the WFD, in the framework of a service contract
- as the basis for the formulation of the WFD rivers' monitoring schedule for the entire third monitoring cycle of the Directive, that is already being implemented

- as the basis for the elaboration of the 2nd Cyprus River Basin Management Plan, in the framework of a service contract

From the above it becomes clear that the project has already made a significant contribution to the preparation of an improved second RBMP, as compared to the first, but also that the project's outcome is already being used to set up further upgraded and targeted WFD monitoring schedules; if these schedules are duly implemented their results are expected to become the basis for enhanced management decisions to be taken in the third RBMP in 2021.

The outcome of the technical part is by now being implemented and an integral part of Cyprus' WFD implementation, and comments received are largely positive. The case of the present study could be characterized as an example where rather simple methods, combined into a complex approach and deeply rooted in measured environmental data, yields very useful results that are totally fit for purpose.

The elaboration of the DProf proposal, i.e. the technical part, and the people related part, i.e. the stakeholder consultation, complemented and provided feedback to each other as follows. The technical DProf components, i.e. the elaboration of the DProf proposal, fed 100% into the stakeholder consultation procedure, which was entirely based on the technical proposal and planned according to its needs. The stakeholder consultation, on the other hand, yielded feedback, even though minor, for the technical DProf components by influencing my approach towards e.g. rather not splitting reaches into water bodies, and by pinpointing issues that needed more attention in the DProf project report than I had been given myself.

The fact that no significant potential negative effects were identified is also an indication that there are no important omissions in the DProf proposal – at least none that would cause resistance on the national level because these would have been identified in the consultation process. This indicates the role of the stakeholder consultation as a reassuring process and in that sense the consultation can be considered as a kind of "safety net" on the national level.

5.2 Recommendations

I recommend the adoption of the technical proposal elaborated by this project and the acknowledgement of the related benefits and potential negative effects for future WFD implementation and river management in general.

In addition, the following recommendations are made:

- To protect and manage the streams that are, in comparison to the stream network of the first RBMP, being removed from the network, as proposed in chapter 4.1.1. These streams are presented in Appendix 10.
- To continue to adjust WFD monitoring based on types and assessment groups (implementation ongoing since Jan. 2015)
- To increase monitoring of Ih and E type in order to allow for proper grouping in 2019 for the third RBMP, and compensate by reducing in types P and I. The successful implementation of the scheme proposed by the DProf project in the two river types with sufficient data, P and I, with respect to status classification and relation of status to pressures, is a strong argument in favour of collecting sufficient data over the coming years for the two river types that lack data up to now, with the prospect to perform an equally successful status classification and identification of status-pressure relationships for all four river types in 2019 for the third RBMP.
- To collect stream flow data from Ih and especially E type rivers to allow for better definition of the types using the TSR method.
- To further sub-divide river type E into ephemeral and episodic rivers. For the third RMBP recommend to review them and check whether some could be removed as water bodies.
- To utilise the mapped succession of flow regimes along the river courses, in connection with information on e.g. fish populations, to protect and enhance critical refugia by e.g. construction of bridges or weirs allowing the migration of all relevant biota along these rivers and by actively improving existing structures.
- To utilise the identified differing views amongst stakeholders for improved water management by adopting decision making mechanisms that facilitate the identification of compromise solutions through dialogue and discussion between all relevant parties.

5.3 Limitations

The simple river typology is applicable due to the small size of the island – in a larger area, further division of e.g. the perennial type would be imperative. In fact, it is clear that in Cyprus rivers more than one perennial flow regime exist (cf. Buffagni et al., 2012) – still, for its clear identification and the determination of its spatial extent there is not enough data and, even if more stations would be installed, the small number of rivers sets a limit to statistical analyses – the number of cases is limited. It is thus anticipated that, even if more perennial types would be identified, this would be types that would represent very few water bodies each – a situation rather unfavourable for rational management. Still, Cyprus would need to set reference conditions for each type; and in case these types turn out not to be different in the end, the need to separate types would vanish.

The assessment groups scheme is applicable only in situations of similar pressures, i.e. where hydromorphological pressures are not evaluated or are not important; in addition, most importantly, ecological status does not consider the BQE fish. These limitations narrow the applicability to specific situations similar to Cyprus.

Chapter 6. Reflexive account of learning and professional journey

6.1 Knowledge and understanding

The “area of practice” of the DProf project is a rather complex one. It comprises several core areas of the Water Framework Directive (Article 5, the intercalibration exercise), the implications of changes in these areas on other parts of the Directive’s implementation (Articles 8, 11 and 13) and in parallel the consultation with the stakeholders, which is interacting with the aforementioned more technical areas. During the course of the DProf project, I have combined the above into findings and output that demonstrate the depth and range of my knowledge in this complex area.

With respect to the scientific level and timeliness, the project deals with issues that are intensely discussed in current literature, namely temporary rivers and in particular e.g. their mapping onto stream networks, but also the issue of water status assessment for unmonitored waters, where literature is scarce but the need for research in the area was highlighted in recent research articles. These subjects can thus be considered to represent the leading edge of WFD related research, and the DProf project has improved professional practice in these fields in Cyprus.

Even though I had already extensive knowledge on the technical part of the DProf subjects before I commenced working on the project, the project required me to explore new depths of the complexity of WFD issues. This is particularly true for stakeholder contacts, the approaches to this subject, what and how to present to stakeholders, as basis for subsequent deliberations and discussion etc. (cf. chapter 4.2.1.3 on 3rd session and chapter 4.2.1.4 on 4th session). In parallel, my day to day work and the coordination of and involvement in related contracts with external consultants provided additional feedback to these deep insights and continuously reframed my approach. In retrospect, I am certain that the intense engagement with the above subjects for the DProf project deepened my specific knowledge and I utilize it on an everyday basis now in my professional practice.

The DProf project was in its entirety embedded in a virtual action research approach, where the technical components were consulted with stakeholders in two AR loops. This overall framework of the project contains several technical components and the consultation process, each of which was addressed with suitable methodologies. This approach forced me to select and combine research and development methods as components that together form the present DProf project.

Looking back on the course of the research work of the DProf project, I realize that the components of the project I had considered, in the project planning phase, to be the most difficult parts did in the end not pose the greatest difficulties. This is undoubtedly true for the establishment of the new river typology where the TSR method of Gallart et al. (2012) provided a straightforward method to accomplish the specific research objective. On the contrary, the two components that dealt with the mapping of river types onto the stream network (chapter 3.1.4) and the development of the assessment groups scheme (chapter 3.1.7) proved to be much more challenging than expected because they required the development of new dedicated approaches that would allow achieving the targeted result with the available data; these parts of the DProf were, in retrospect, truly “stretching” experiences that called for all my intellectual capacity.

In a similar sense, the adjustment of the initially planned action research programme with respect to the progress of the development of the technical components (chapter 3.2.1) as well as the modification of the virtual AR approach by presenting to the stakeholders a real implementation of the DProf outcome, instead of resorting to explaining potential impact and effects in a “virtual” way (chapter 3.2.2.2), were very challenging experiences. However, despite feeling a bit like a fish out of water (and empathizing with the fish, being a water-loving hydrologist) when I had to perform in these for me unknown fields of research, the results demonstrate how I developed new approaches in new situations and how I flexibly amended planned approaches to adjust to the project’s dynamic development. Upon reflection it becomes evident that the modification of the virtual action research approach, after three consultation sessions, could be seen as an ad hoc development of research methodology based on the practice and experiences of the three first consultation sessions.

It seems worth mentioning that the requirement of the DProf project to achieve a result that covers the entire WFD stream network introduced difficulties because it required finding solutions to address marginal cases and using expert judgement, e.g. the criteria for assessment groups of Ih and E types. Further contemplation about this topic leads to the conclusion that this characteristic of the present DProf project sets it apart from a pure research project (e.g. PhD) because it indicates the need to cater for actual implementation of the DProf’s results, including also the “marginal” cases without much scientific evidence, which in turn incurs the need to resort to e.g. expert judgement to achieve this; a PhD project, on the contrary, would perhaps stop right before stepping into the territory of ambiguity and using “expert judgement” without hard evidence.

The stakeholder consultation revealed different views amongst the stakeholders, both between participants from the same organizations (including my own organization) but also in general amongst them. Contemplating about these differing views leads to the insight that they represent conflicting values for, speaking in crude categories, more protection of the environment on the one hand and for easier implementation of development works on the other hand. These conflicting values between "development oriented" and "protection oriented" stakeholders are certainly typical and common in the professional practice of environmental management. After taking into consideration the findings from the stakeholder consultation, it becomes clear that I had, from the beginning of the consultation process, proposed solutions that are more or less mid-way between the opposed views of the stakeholders. These solutions were discussed and scrutinized in the stakeholder consultation sessions and can thus be considered to have been agreed in dialogue with the stakeholders. Interestingly, the researcher had, largely, proposed these solutions already with the initial technical proposal in the first loop of stakeholder consultations, even before the different views amongst stakeholders emerged (cf. the discussion about network density in the 1st stakeholder consultation session).

Thinking further about the reasons for this happening suggests that it is at least partly a result of my "intermediate"position as practitioner-researcher. In this position, on the one hand I promote environmental protection according to my personal values but on the other hand I am well aware of Cyprus' obligations towards the E.U. and the limited resources and constraints to achieve them, in my position as responsible officer for WFD monitoring; in this position, I recognize the dangers of a too dense network, overburdened with small stream reaches that can hardly be assessed thus creating problems for justifying the lack of results for them. Concluding from the above it becomes clear that I am myself in the very middle of the two extremes and for that reason, I may have unconsciously created a "medium solution", right between the two conflicting parties within the WDD. This insight, upon reflection, also reveals how and to what extent my very position within my organization influenced the DProf proposal and finally the project's outcome.

6.2 Cognitive skills

I felt the necessity to develop methodologies that would allow achieving the DProf project's objectives within the context and the constraints of the complex area of the Water Framework Directive, as had been described in chapter 6.1 above, as a considerable challenge. However, the outcome of the DProf project illustrates how I have coped with these challenges and how I have accomplished analysing and synthesizing this complex information for the development of new approaches and finally for the establishment of new knowledge. In the case of the difference in views on the stream network density amongst the stakeholders, which can well be interpreted as conflicting ideas and values, I have synthesized these conflicting ideas into mid-way solutions.

I have worked with stakeholders in a consultation process that comprised of five sessions. Based on the findings of the process, I consider that all significant stakeholders, i.e. the entire "critical community" of WFD implementation in Cyprus, were included in the consultation. Even though feedback did not reach the expected extent and contribution was rather small in the end, the dialogue and discussions that emerged illustrate that the stakeholders were part of the establishment of the new spatial basis of rivers monitoring and management. Upon further reflection on the role of the stakeholder process within the DProf project, I realized how much I experienced it as a reassuring process indicating to myself that the technical proposal did not stray into unacceptable grounds, at least for national stakeholders.

My engagement with the issue of stakeholder and public consultation and participation has definitely increased greatly my knowledge on the subject. In particular the analysis of the sessions' transcripts was new terrain and seemed "strange" or "foreign" to me, because as a hydrologist I was not used to analysing material in the subjective way this is done, when coding and analysing retrieved chunks of text. It was a challenge to adjust to "deal with ambiguity" and with the fact that "coding and codifying are not precise sciences with specific algorithms or procedures to follow" (Saldana, 2009, p.29), but it was definitely worth the effort and opened new ways of knowledge generation to me, thus increasing my capabilities and awareness for interdisciplinary work.

The work on the stakeholder consultation has changed my perception and approach to participation under the WFD. Before, my perception was mainly influenced by the experience and narratives from my (mainly engineer) colleagues who had been running the participation process in Cyprus for the first RBMP and they more or less presented it as useless and waste of time. Now at the end of the DProf project, I have my own experiences and I am aware of the difficulties involved in engaging with stakeholders about technically difficult subjects, and I anticipate how much effort and time it would be needed to achieve significant stakeholder contributions in the Cyprus context.

Contemplating in a general fashion about the DProf project reveals that my self-appraisal and reflection on practice have had its contribution to the course of the project. For example, self-appraisal during the stakeholder consultation process led to adjustments of my own acting and practice (cf. between sessions 1 and 2), while reflection about the acting of participating stakeholders allowed identifying their motives.

A reflective appraisal of the development of the DProf proposal and the stakeholder consultation process reveals that I had a decisive influence on the outcome. The approaches I chose were doubtlessly rooted in my values, my professional background, the fields I have worked in and the personal experiences I have gained from them. This conclusion becomes even clearer and is supported by the insights gained from the stakeholder consultation, which revealed that even colleagues who hold equivalent positions as myself in my organization, but have different responsibilities, have divergent opinions about certain aspects e.g. the ideal density of the WFD stream network. Such different views seem to origin, based on the understanding obtained from the consultations, at least partly from the specific professional field, within the responsibilities of a hydrologist at the Water Development Department, which the colleagues and I myself work on: monitoring, issues of flood protection, water abstraction permits, issues of water systems protection or issues with land owners trespassing onto neighbouring watercourses. Each colleague would, based on his own personal professional experience, certainly choose different approaches or take different decisions as the ones taken by myself.

Still, the comprehensive study of the pertinent normative framework of the WFD and the Guidance Documents I had undertaken, as well as my experience on the DProf’s topics from my participation in pertinent E.U. Working Groups, which my colleagues do not have, has to be factored into the above reflection. If my colleagues would have this specific knowledge it is likely that their opinions would have converged to a greater extent with my positions. In other words, this accumulated specific knowledge on the DProf’s topics would most probably have reframed their views towards the approaches proposed by myself.

The gap in specific knowledge between me and the stakeholders was also expressed in the stakeholder consultation:

> “To be honest, because you have studied the subject in depth, the last word is yours, whatever we say, because we ..., we have some idea now at this moment...the opinion with the highest weight is yours” (Senior Hydrologist #1, 1st session)

Another stakeholder remarked on the added value gained for the quality of the result that is due to my experience:

> “It became clear that, because YOU did it with all your experience from the past, the result reflects that” (Senior Hydrologist #2, 3rd session)

Contemplating about the above quotes, however, I have no doubt that such comments would as well have been made if a different colleague would have undertaken to elaborate the proposals for changing the spatial basis of rivers monitoring, which would certainly have been different from this study. The quotes of the stakeholders are not so much an acknowledgement of the proposal itself but of the knowledge that led to its elaboration, independently from the person having the knowledge.

I have organized, carried out and completed a quite complex DProf project which indicates my capability for autonomous management of my own learning. Still, I sought support in areas where this was available e.g. for the final mapping of river types the advice from several local people with in-situ knowledge was utilized.

Upon reflection I find that at several points along the course of the DProf project, I felt “too autonomous” and would have appreciated more interaction and discourse, but this was not possible due to lack of knowledgeable colleagues; the following incident is pertinent to this issue:

As a member of the steering committee of the contract for the elaboration of the second Cyprus RBMP, I was involved in numerous discussions with the respective consultants from Greece because their work is based on the DProf outcome. At the end of the meeting, a member of the consultant’s consortium approached me and asked if there wasn’t any resistance from Cyprus Universities and Research Organizations when I proposed changing the river typology. The issue had caused her attention because, as she mentioned, this issue was the reason for large dispute between different University professors in Greece and they had not managed yet to resolve on the issue. I explained to her that Cyprus Universities and Research Organizations do not deal with specific issues of the WFD at all and thus have no relevant expertise. I also told her that the situation was quite the opposite: I would have liked to have feedback and discussion with knowledgeable persons but there weren’t any, as it became apparent form the stakeholder consultation. Another consultant remarked that this sounds like a situation of “loneliness” and, upon reflection, I would agree that the DProf project at some stages indeed felt like that.

For an interpretation of the incidence, the situation in Greece must be evaluated in relation with the country’s huge variety from North to South, which is not at all comparable to the small scale of Cyprus. In addition, three issues come to mind: First, the fact that there was no resistance in the process in Cyprus allowed for a swift elaboration and also implementation of the new typology – a situation as the one in Greece without resolving the dispute, as described by the consultant, would undoubtedly have had detrimental effects on the DProf project. Secondly, constructive dialogue with knowledgeable colleagues would definitely have been welcome, but it did not occur despite the dedicated consultation process. Third, the situation in Cyprus is not directly comparable to other EU countries, like Greece, because of the lack of Cyprus Universities and Research Organizations in Cyprus that deal with issues pertinent to DProf subjects. Upon reflection, the above considerations illustrate the substantial impact of the specific Cyprus context on the course and outcome of the DProf project – clearly it is very likely that the project, if undertaken in another E.U. country, would have taken a different course.

Further contemplation about the topic indicates that the situation in Cyprus allows for considerable freedom for civil servants in shaping policy and technical solutions for many specific technical policy issues, because there is neither input nor resistance from the local scientific community, simply because the latter does not exist with respect to many scientific fields. The downside is of course that scientific dialogue and critique is missing which leads undoubtedly to less-than-perfect solutions.

The establishment and mapping of the temporary river types has provided the basis for discussion amongst the stakeholders about the future treatment of each distinct river type in the framework of WFD implementation. Different views on the subject exist and the differences could not be bridged during the stakeholder consultation. These conflicts still remain unresolved and create "opposed fronts" amongst the stakeholders but also within the researcher's own organization. Contemplating about the above situation, I am well aware that the DProf proposal has caused these "political implications". However, I definitely do find a positive side of the DProf project's role in this situation, because it achieved to spark discourse about river management in Cyprus and revealed the different interests present amongst the stakeholders, which will, hopefully, in the future lead to improved stakeholder-driven river management.

The DProf project included points where I had to take decisions about the further course of the project through the evaluation of different alternative approaches. Due to the nature of the DProf project, i.e. the predefined sequence of components that would lead to the final outcome, at the end of each component I had to accurately assess my own work, judging whether the intermediate result is mature enough and suitable to be used as the basis for the next component. Obviously, for each new component, I had to evaluate all available alternative approaches before proceeding to implementing the selected one.

In retrospect, I remember these phases of accepting intermediate results in order to move on to the next component as very difficult periods. In particular the pressure to deliver the agreed outcome to the WDD in time in combination with the uncertainty whether the decision taken may be proven wrong by the next component, put a large strain on me. One pertinent example of evaluating alternative approaches is the selection of the method to be used for the new river typology as described in chapter 3.1.3, where I used and tested the TSR method of Gallart et al. (2012), compared it to cluster analysis, before adopting it and in parallel providing justifications for its selection.

6.3 Generic skills in the area of professional practice

The accomplishment of the DProf project's objectives necessitated innovative approaches, in particular with respect to the development and application of the methodology for the mapping of the stream types onto the stream network, i.e. the "tiered approach" (chapter 3.1.4) and of the methodology for the elaboration of the assessment groups scheme (chapter 3.1.7). The "tiered approach" refers to issues intensely discussed in current literature, namely temporary rivers and in particular e.g. their mapping onto stream networks; it was synthesized from the outcome of the work on river typology and the identification of suitable data, which would allow assigning the stream type in the most reliable way to every single river reach, and is considered a new approach to stream type mapping. The assessment groups scheme addresses a topic that was recently put forward as subject that needs more research for improved further WFD implementation in the scientific literature.

Interdisciplinary understanding was and is part of my work and also of the DProf project. Due to my responsibilities and position in my organization, I am bridging the prevalent engineering approach of the Water Development Department with the ecological point of view required for the implementation of the Water Framework Directive. These interdisciplinary approaches were also necessary in the stakeholder consultation where different disciplines, e.g. engineering, hydrology, agriculture and environmental protection, met and cooperated for the stakeholder consultation under my coordination.

The DProf project has utilized a wide range of resources covering scientific literature, numerous local data (hydrologic, pressures, land use, census data, etc), numerous maps and digital spatial datasets (GIS), knowledge on local conditions from local experts, contributions from stakeholders. The specific way of combining data resources for the development of the assessment groups scheme, i.e. water status data and a range of pressure data, may well be used by other researchers in the future. In a similar sense, the way in which different data resources, in this case stream flow data and various environmental data representing catchment characteristics, were applied for the different tiers of the "tiered approach" for mapping stream types onto the stream network could be adopted in future studies too.

As the DProf project went on and results and outcome became available, I had communications with several colleagues. There were email exchanges with colleagues abroad (cf. chapter 3.3) about two of the main subjects of the DProf project, namely typologies of Mediterranean rivers and the assessment groups scheme, and I also had informal discussions at the E.U. working group meetings as well as at meetings at the European Environment Agency where I attend as representative of Cyprus, during which I had the opportunity to mention, explain and discuss my DProf work. In retrospect, these professional and academic communications were reassuring for me because they allowed me to explain my work for the DProf project to colleagues working in the same professional field and their positive and interested response encouraged me that the project is at least broadly following a reasonable course. At the national level, the stakeholder consultation process required me to give presentations to the “critical community” of stakeholders. The stakeholder consultation had, in addition to identifying benefits and potential negative effects of adoption of the researcher’s proposal, also the objective to seek contributions for the development of the new spatial basis for rivers monitoring and management.

I developed the proposal for the new spatial basis for rivers monitoring and management in autonomy but within my professional environment. I developed the proposed scheme based on my first-hand knowledge of the situation at my workplace including the various constraints. In retrospect, it was my knowledge that allowed to elaborate the proposal in a responsible way in the sense that it was adapted to the constraints posed by resource availability, that it was adapted to the environmental framework given by the rivers to be monitored and managed according to the proposed scheme and that it does not bear an increased risk of potential negative effects e.g. opposition or, at worst, rejection from the E.U.

With respect to potential negative effects, reflection reveals that it had been rather unlikely that I would have, given my practical experience in the WFD implementation as pertinent to the DProf project in Cyprus and my awareness of the stakeholders' way of thinking, proposed a new scheme obviously causing negative effects, which would be detected by national stakeholders. However, it could not be excluded beforehand that some new opposition or dissent would emerge, sparked by exposition of the stakeholders to the new material presented by the DProf project, and finally persistent differing views amongst stakeholders were indeed identified.

As a responsible civil servant, I consider it inappropriate to propose or support a solution that bears an increased risk of causing opposition of or, at worst, rejection by COMM – such a decision would have to be taken on a higher level. With respect to the specific question that emerged in the stakeholder consultation whether to remove more or even all ephemeral rivers from the proposed WFD stream network, any further removal of streams would have meant breaching the consistent application of the quantitative criterion of stream selection, thus invalidating its use for justification of the removal of the small streams and tributaries that was included in the initial proposal and I would not have agreed to such a proposal. This case allows insights into my values: I value compliance with E.U. obligations and accurate and reliable results of my work higher than reducing effort, i.e. mainly cost, whatever the negative impact may be. Considering the project’s impact on these values, I reckon that these have not changed, but through the engagement with them I have certainly become more aware of them.

The proposal of a new scheme for rivers monitoring in Cyprus that fundamentally changes the scheme that was in place before and that, as was acknowledged by the stakeholders in the consultation session, will certainly improve WFD implementation in Cyprus, may well be interpreted as the result of my personal leadership, with respect to advancing river monitoring and management on the island.

The DProf project has certainly changed me as a professional. This is especially the case for my approach to new problems to be solved, problem formulation and for solution planning. Upon reflection it is apparent that this change was brought about by my engagement with research methodology and my work on the stakeholder process. These parts of the DProf project widened my horizon with respect to methodological approaches and especially about social science methodologies. Now, after the DProf's completion, when I approach a new problem I customarily take a step back and look at the matter from a more distant perspective and with a wider horizon. I strive to take into account the social science aspects, in addition to the natural science part that would correspond to my previous professional life and academic education. Even though in my own professional practice I can only rarely implement social science methods, the very awareness of the methods, their capabilities and of the results they can yield enhances my contribution to the professional practice of my professional field i.e. policy formulation and problem solving in the management of water and aquatic environments in Cyprus. Within the above process, I have made conscious reflection a regular part of my practice; I would pause for a moment and reflect about values, aims and interests of involved parties and reflection would also address putting the issue at hand into its wider environmental, economic and societal context.

The DProf project, through the consultation sessions, placed me in the Cyprus' spotlight as an expert on the island's rivers, their typology, the pressure-impact relationships etc. This process gave me the opportunity to convey not only the technical proposal but also my personal values and standpoints with respect to my professional field to the local stakeholder community. It can be considered certain that after the stakeholder consultations I am regarded as the local expert on Cyprus rivers, their characteristics and types and the relationships between pressures and river quality, at least in a WFD context. In addition to the local level, the DProf project helped me to develop a voice in the European WFD community by providing the opportunity to present and discuss the project through contacts with colleagues abroad (cf. e.g. chapters 3.3 and 6.3 further above). I am normally rather reluctant to put forward opinions or critique unless I can base them on thorough personal knowledge of the matter at hand. The successful completion of the DProf project definitely increased my confidence in my corresponding extensive knowledge and comprehension of the concerned subjects and I therefore feel highly confident to speak up when these topics are discussed and to take initiative to put forward my own views and to critique proposals of others. Thus the DProf project has liberated and greatly strengthened my voice on the pertinent subjects and subsequently increased my contribution to these subjects.

With respect to reflection, I found that the most productive time to contemplate about various issues of the DProf project was while washing the dishes. The latter was a quite regular task because of a broken dishwasher in my household. Further thoughts about the issue yielded a possible explanation, namely that the entirely mechanic task of washing dishes frees the mind for deep contemplation, completely decoupling the manual labour from the thinking process. Still, this specific practice raises issues of increased numbers of broken dishes and of putting the computer at risk by typing with wet hands, dripping watery detergent on the keyboard; however, these issues were not further examined in the present report.

6.4 Researcher's knowledge gain and repercussions on DProf project

The DProf project proposes quite far-reaching changes to basic elements of the large and complex system of WFD implementation and as a result I was getting involved in issues that are not strongly related to the DProf project itself but that bear some relation to it. As this process went on, I felt to being considered as the expert for too many things and as being called upon for too many cases. This, in turn, affected the progress of the DProf project because the increased workload limited the time left for my own office work, that subsequently too often got shifted into the afternoons and evenings, and this time could not be utilized to work on the DProf project, let alone the increased overall fatigue from the increased workload. On the other hand, I found it difficult to not get involved into issues because I felt that I could make significant contributions.

One specific example is the rivers monitoring programme for the third RBMP (cf. chapter 4.4.3). This is a clear outcome of the DProf project because if there were no new river types and water bodies, and no assessment groups then there would have been no base to establish such a new rivers monitoring programme. Thus, while this is clearly a positive effect of the DProf project, on the other hand it was also delaying the progress of the DProf itself, in the abovementioned fashion, because I had to elaborate the adjusted monitoring programme in late 2014/early 2015 in order to collect data in time for the third RBMP, and it took time that could otherwise have been spent on working on the DProf project. Consequently, I consider this a repercussion of the DProf project on its own progress.

In the same sense, I ended up providing much input into a contract by supporting the contractor to relate the pressures on water systems to water status, similar to what I had done in the DProf project. To this end, I had finally requested the relevant input data from the contractor and done the analysis myself and sent it to the contractor to convince him that the approach is possible (cf. chapter 4.4.2).

The above situation also provides an insight into the staff situation of the Cyprus civil service after several years of economic crisis and related austerity, where the existing staff has to cope with any new obligations that emerge in addition to existing work.

6.5 "Consequences of the DProf project" - Developments after the submission of the technical DProf proposal

After I had submitted the technical DProf proposal to the WDD, in draft format without the results of the stakeholder consultation at that stage, a consultant had been awarded the elaboration of the second Cyprus RBMP and expressed an idea for removing more ephemeral water bodies and/or streams. While the proposal had been agreed in the first and second loop of stakeholder consultations and had already been utilized by two subsequent contracts (contract YY02/2013 on water status classification and contract YP01/2014 for the update of pressures and impacts, cf. chapters 4.4.1 and 4.4.2), one stakeholder, a colleague of mine who also had agreed to my proposal in the stakeholder consultations, immediately grabbed the opportunity of the consultant's idea to push again for removing more ephemeral water bodies and/or streams.

The consultant's entry to the stage had somewhat changed the "balance" of the stakeholder's discussion on the issue, because for the first time a party entered the game that was able (because the technical knowledge is missing in Cyprus) and willing to put an alternative suggestion in writing. This opportunity was exploited by the abovementioned stakeholders to restart arguing in favour of a sparser stream network. One of the driving forces behind their action is that in case of proposals for water development projects in a certain area, it is easier to get the project approved if there is no river water body in the area because then the Department of the Environment does not have to approve it under the strict WFD Art 4.7 environmental permitting procedure. It is clear thus, that this group of stakeholders puts higher priority on "ease of pushing forward water development projects" than on checking the environmental impact of such projects in the process of their approval (which may very well be granted).

This development indicates that the agreement on the proposal reached with the participants of the stakeholder consultation is not very stable and participants may challenge the decisions by utilizing new information from new stakeholders joining the process. This may especially be the case for participants of the DProf consultation who may not have found support by other participants in the DProf stakeholder consultation, and as soon as they encounter "new" stakeholders with similar views, they may call upon the issue again using the support from the new stakeholders.

With respect to the dynamics involved in this process, it should be kept in mind that it was the DProf project's outcome that provided the basis and material for the discussion about retaining or removing ephemeral rives from the stream network in the first place, by identifying the river type and mapping it onto the stream network. Without river types assigned to water bodies, it would have been unknown where these rivers are located and discussion would have been without spatial basis. Therefore, this discussion shows the DProf project's contribution to the discourse about river management in Cyprus but it demonstrates, also, how its outcome causes repercussions on itself.

In all the discussion and conflicts/dissent about the removal of the ephemeral rivers, it became largely forgotten that my proposal itself already included the removal of small streams and tributaries, in response to relevant proposals in the first RBMP (Karavokyris & Partners Consulting Engineers S.A. and Kaimaki, 2011b) and by consistently applying the $10km^2$ stream identification criterion adopted in this study. I felt the sustained pressure for removing more streams and water bodies from the network like certain stakeholders consider the ever further "pruning" of the stream network and reduction of water body numbers as a "holy mission" for a smaller WFD stream network, which became an end in itself. In that sense, after the removals proposed by myself, these stakeholders may well have thought "now we have achieved first removals, why not push for more?"

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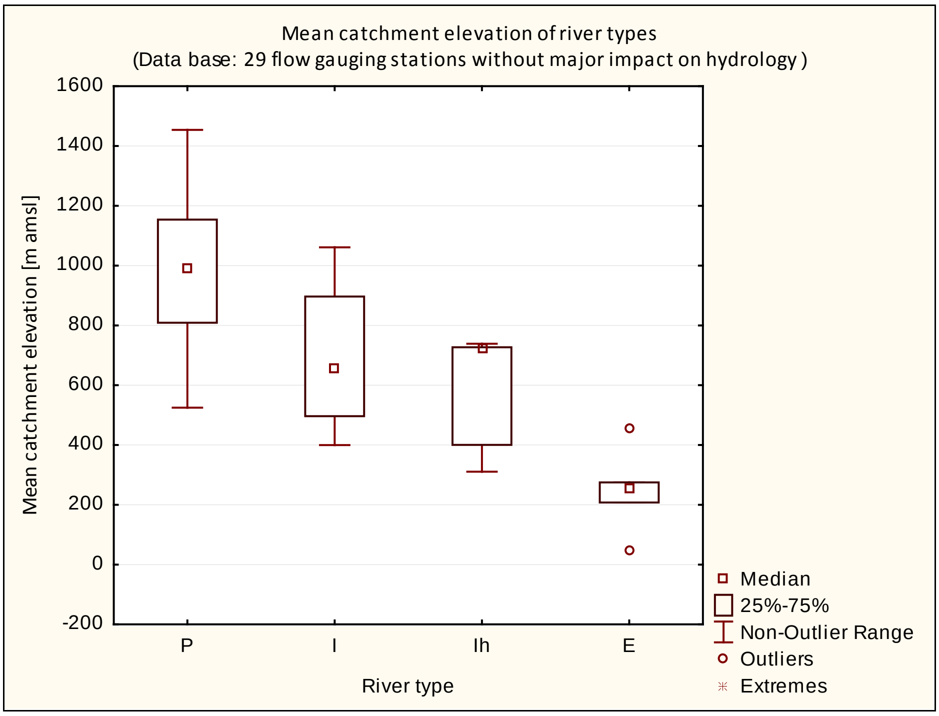
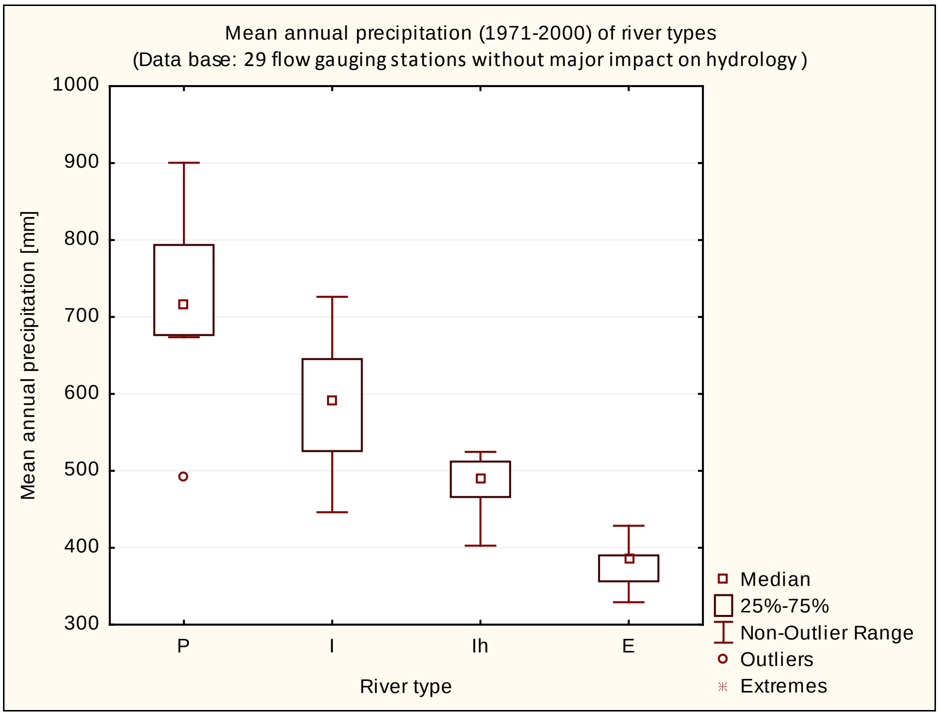
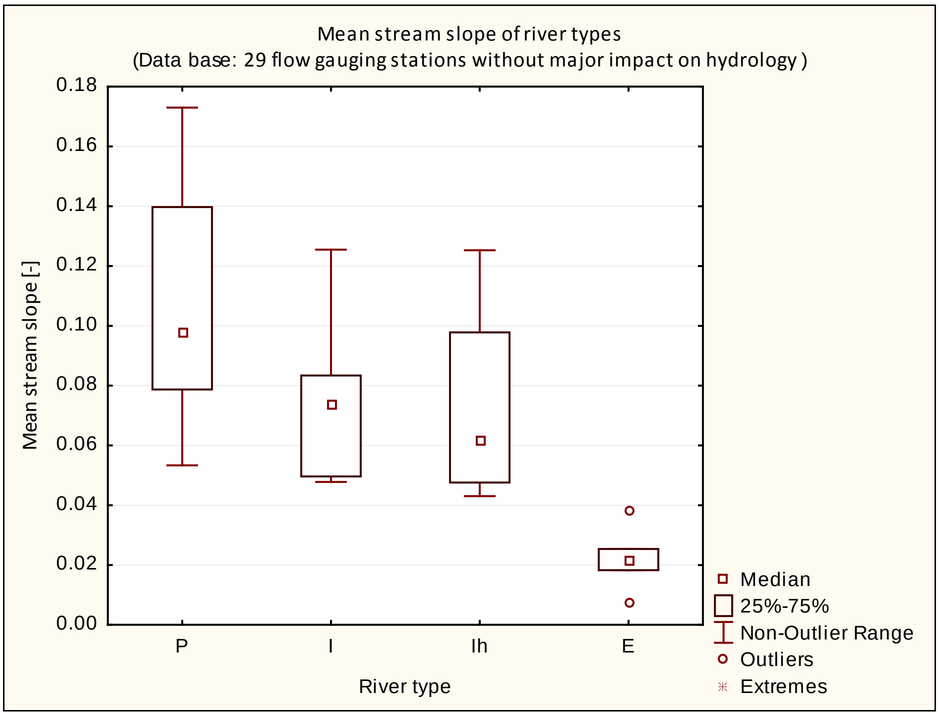
APPENDICES

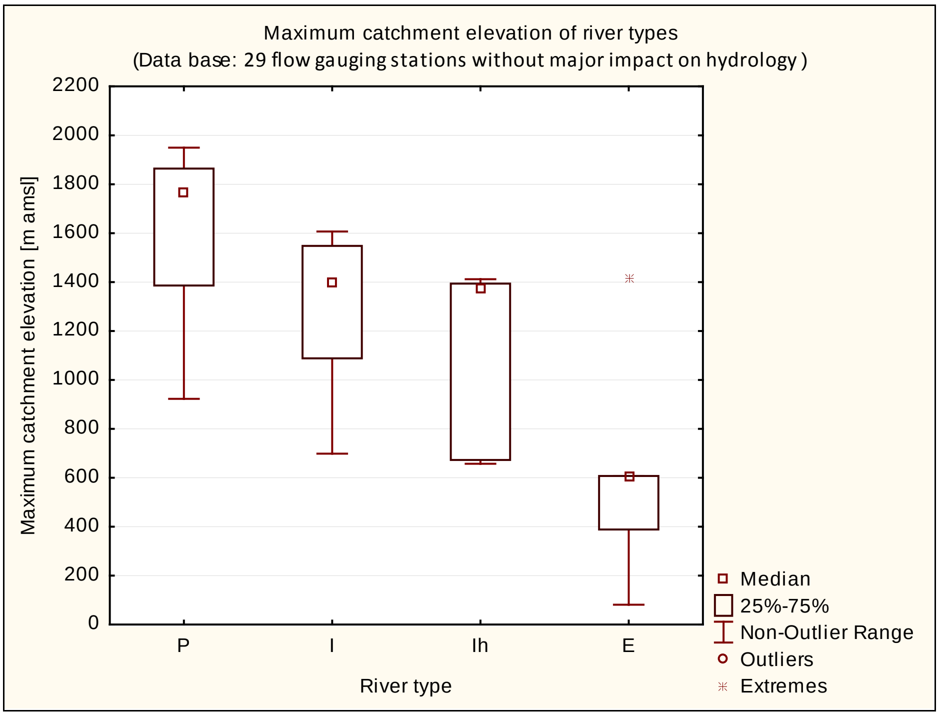
Appendix 1 Graphs of catchment characteristics vs. river type (Data base: 29 flow gauging stations)

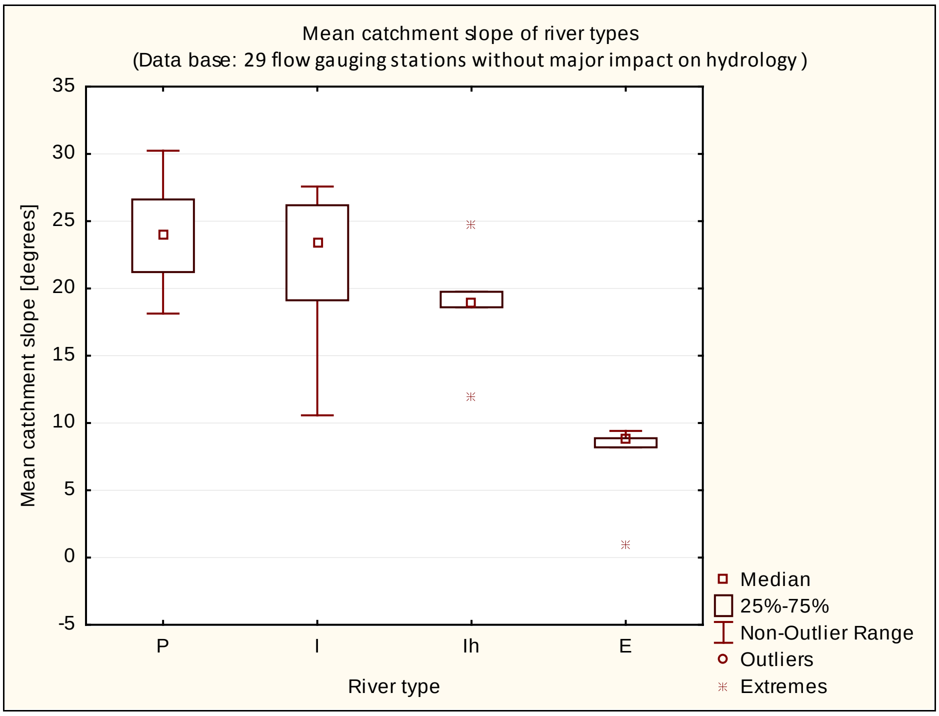
The flow gauging stations used for the determination of the catchment characteristics correspond to the group of 29 flow gauging stations without major impact on hydrology (cf. chapter 3.1.3).

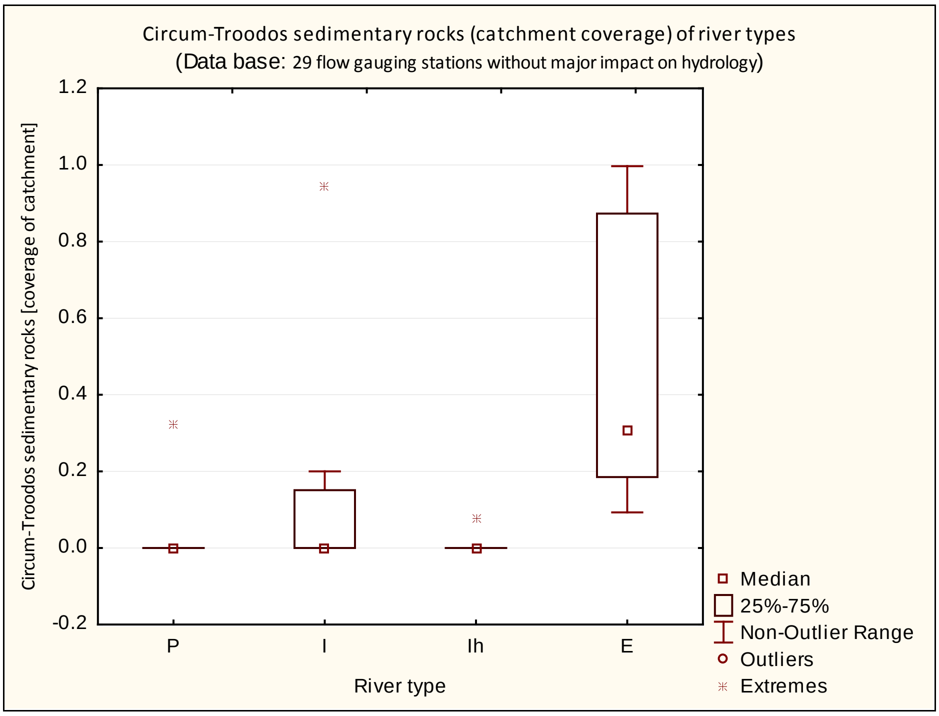


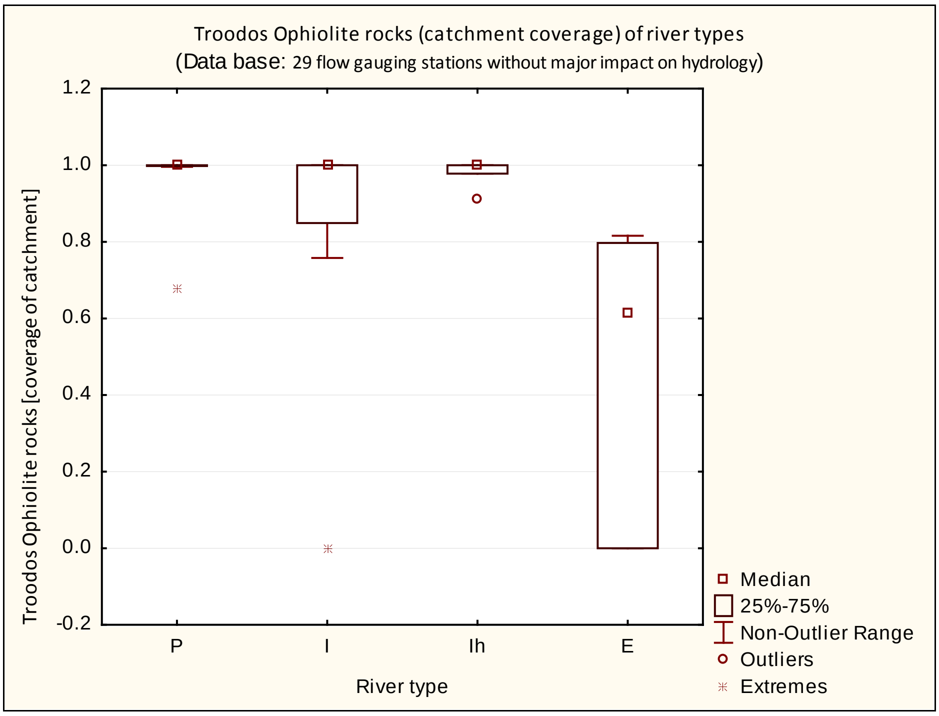


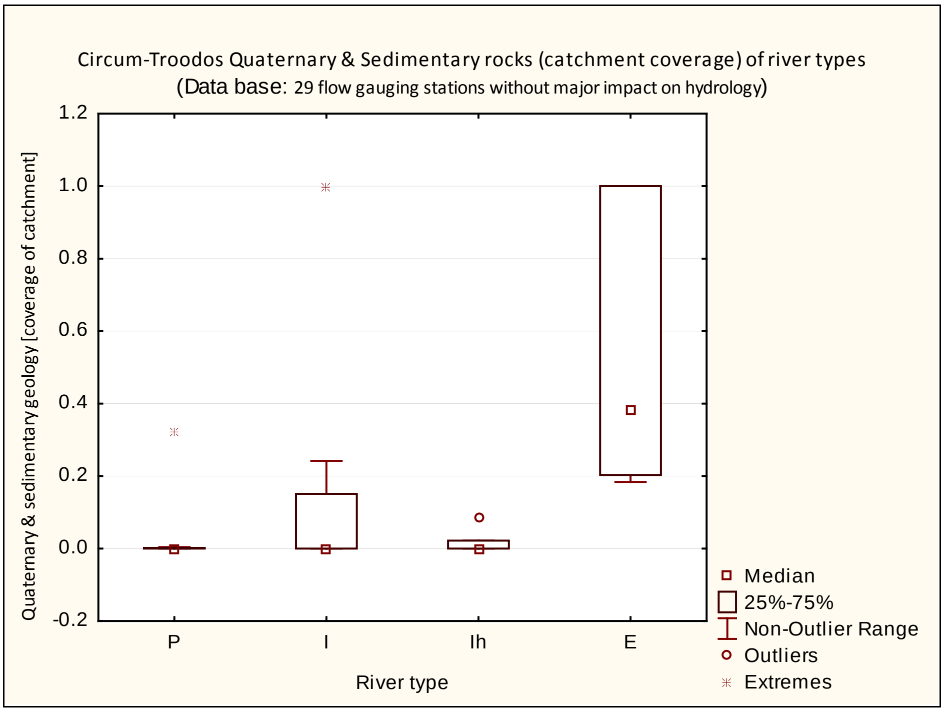

Mean stream slope of river types
(Data base: 29 flow gauging stations without major impact on hydrology)
Mean stream slope [-]
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
P
I
Ih
E
River type
Median
25%-75%
Non-Outlier Range
Outliers
Extremes


Maximum catchment elevation of river types
(Data base: 29 flow gauging stations without major impact on hydrology)
Maximum catchment elevation [m amsl]
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
P
I
Ih
E
River type
Median
25%-75%
Non-Outlier Range
Outliers
Extremes


Mean catchment slope of river types
(Data base: 29 flow gauging stations without major impact on hydrology)
Mean catchment slope [degrees]
35
30
25
20
15
10
5
0
-5
P
I
Ih
E
River type
Median
25%-75%
Non-Outlier Range
Outliers
Extremes

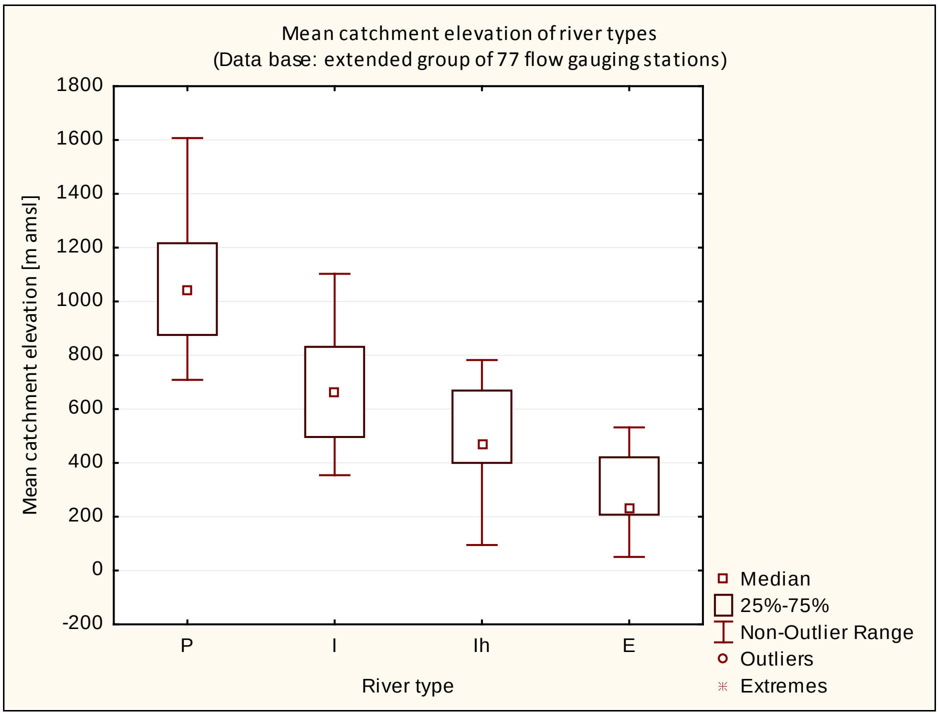

Circum-Troodos sedimentary rocks (catchment coverage) of river types
(Data base: 29 flow gauging stations without major impact on hydrology)
Circum-Troodos sedimentary rocks [coverage of catchment]
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
P
I
Ih
E
River type
Median
25%-75%
Non-Outlier Range
Outliers
Extremes

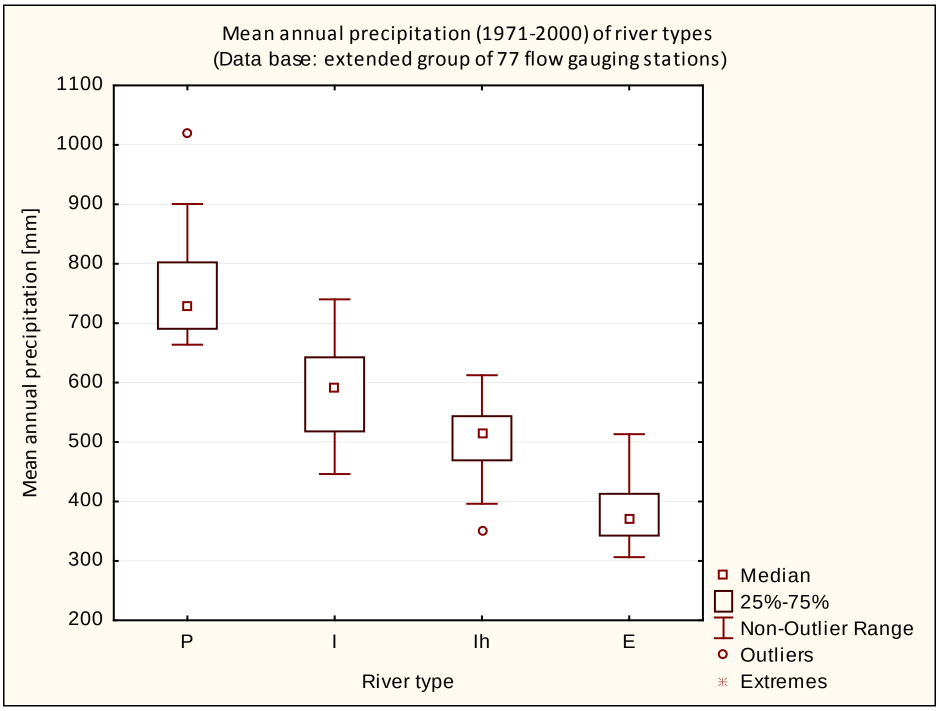

Troodos Ophiolite rocks (catchment coverage) of river types
(Data base: 29 flow gauging stations without major impact on hydrology)
Troodos Ophiolite rocks [coverage of catchment]
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
P
I
Ih
E
River type
Median
25%-75%
Non-Outlier Range
Outliers
Extremes

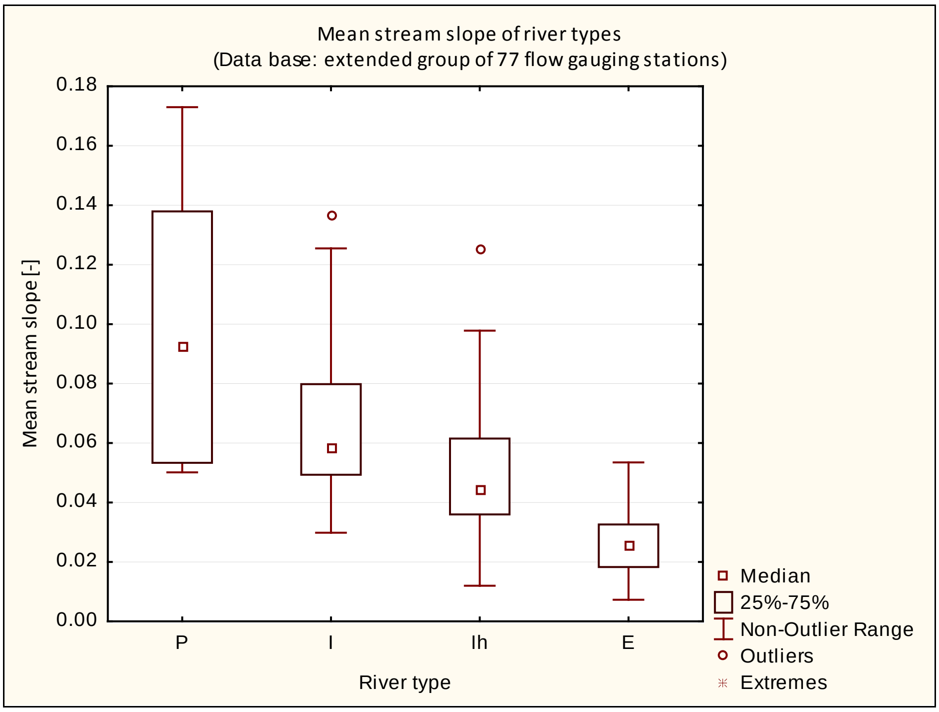

Circum-Troodos Quaternary & Sedimentary rocks (catchment coverage) of river types
(Data base: 29 flow gauging stations without major impact on hydrology)
Quaternary & sedimentary geology [coverage of catchment]
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
P
I
Ih
E
River type
Median
25%-75%
Non-Outlier Range
Outliers
Extremes

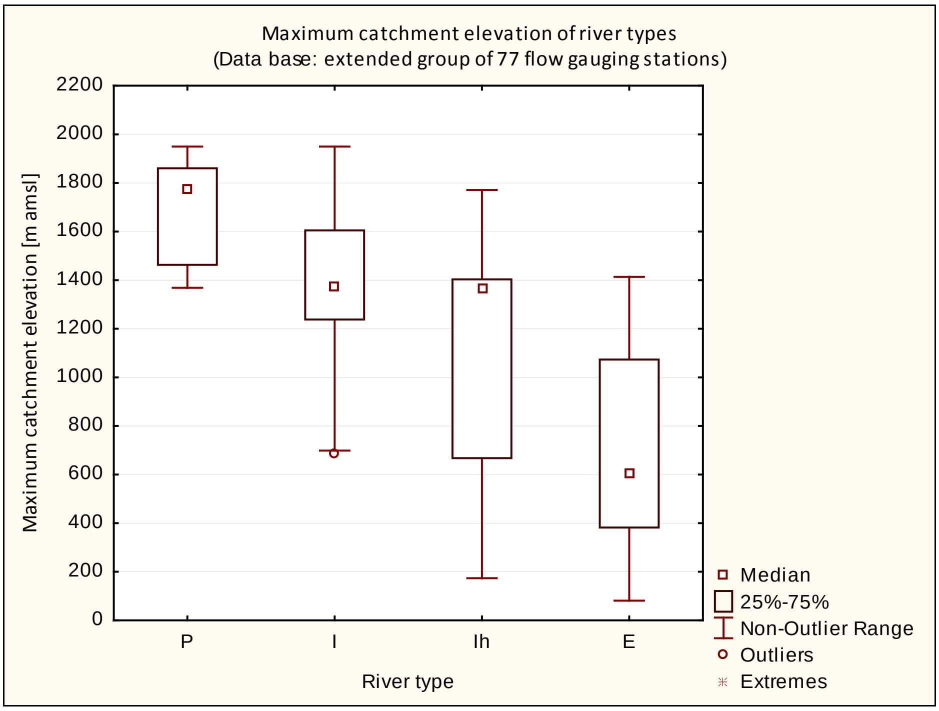
Appendix 2 Graphs of catchment characteristics vs. river type (Data base: 77 flow gauging stations)

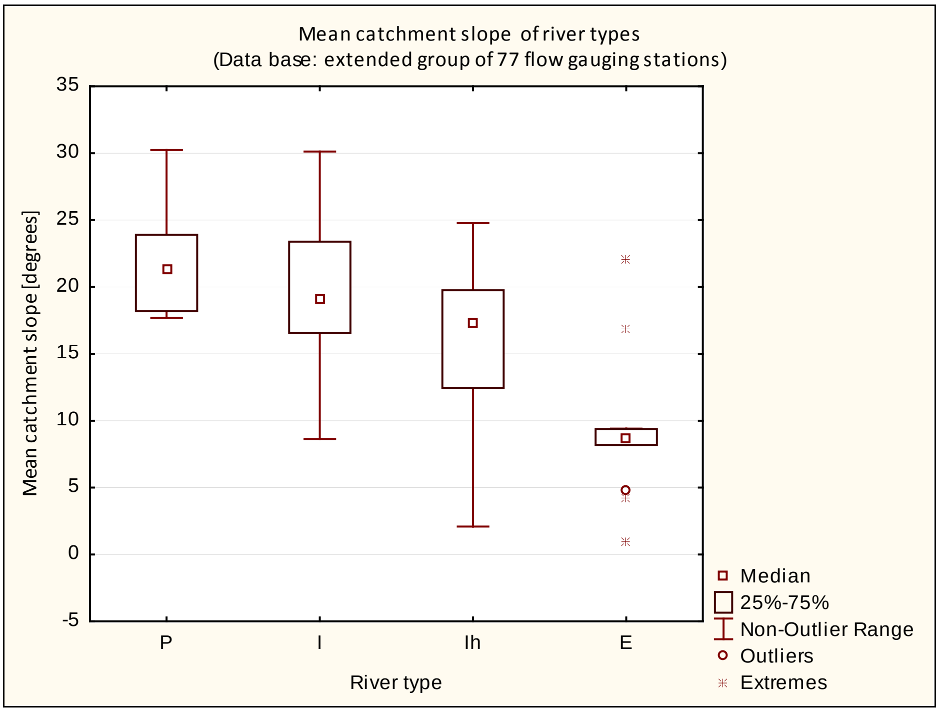
The flow gauging stations used for the determination of the catchment characteristics correspond to the extended group of 77 flow gauging stations without major impact on hydrology (cf. chapter 3.1.4).

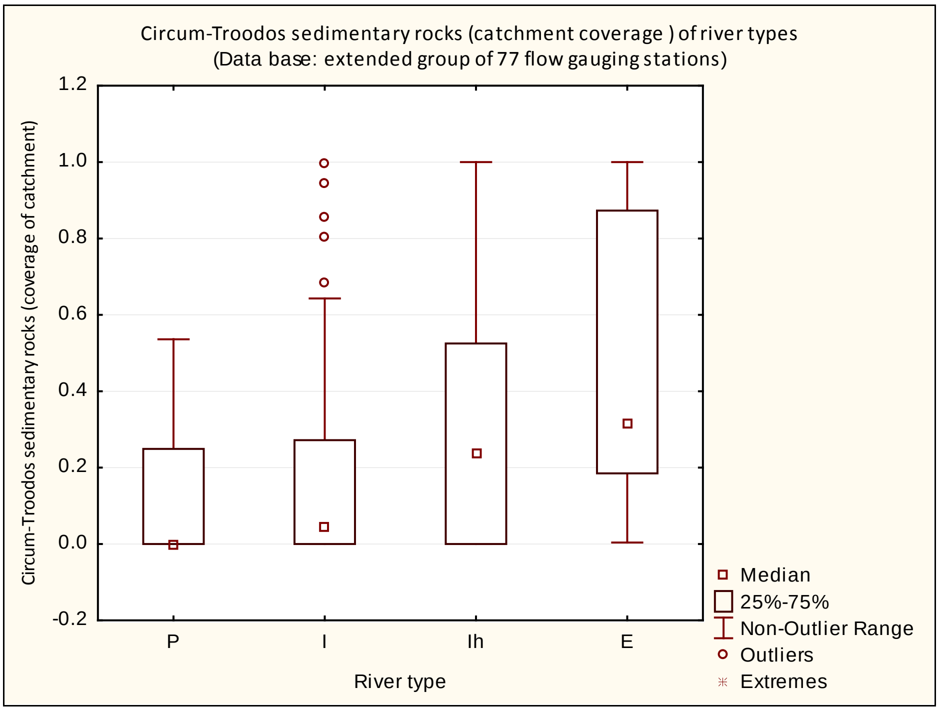


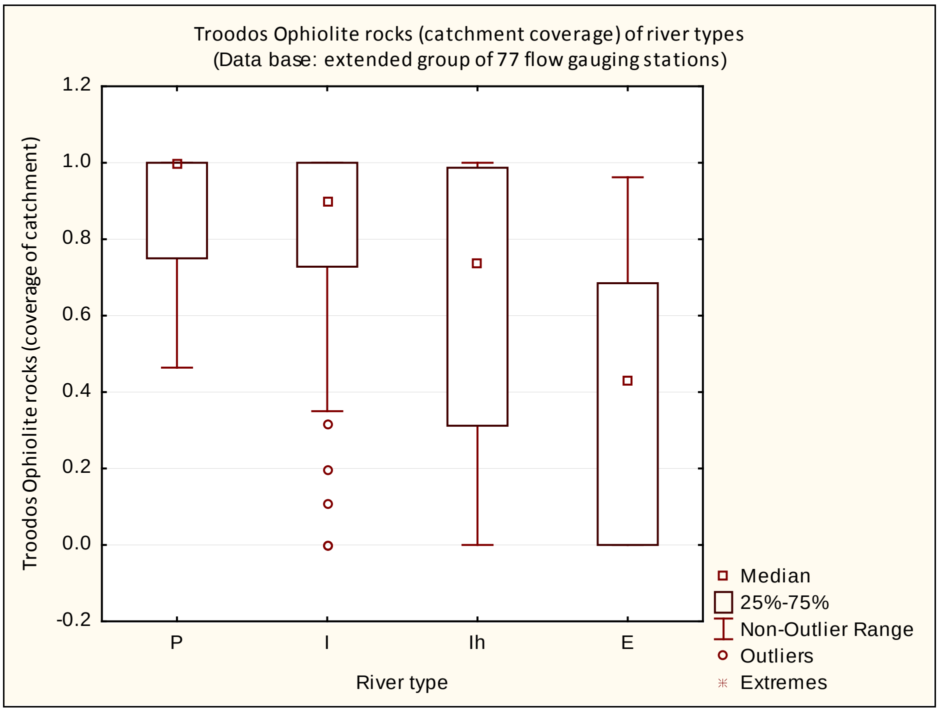


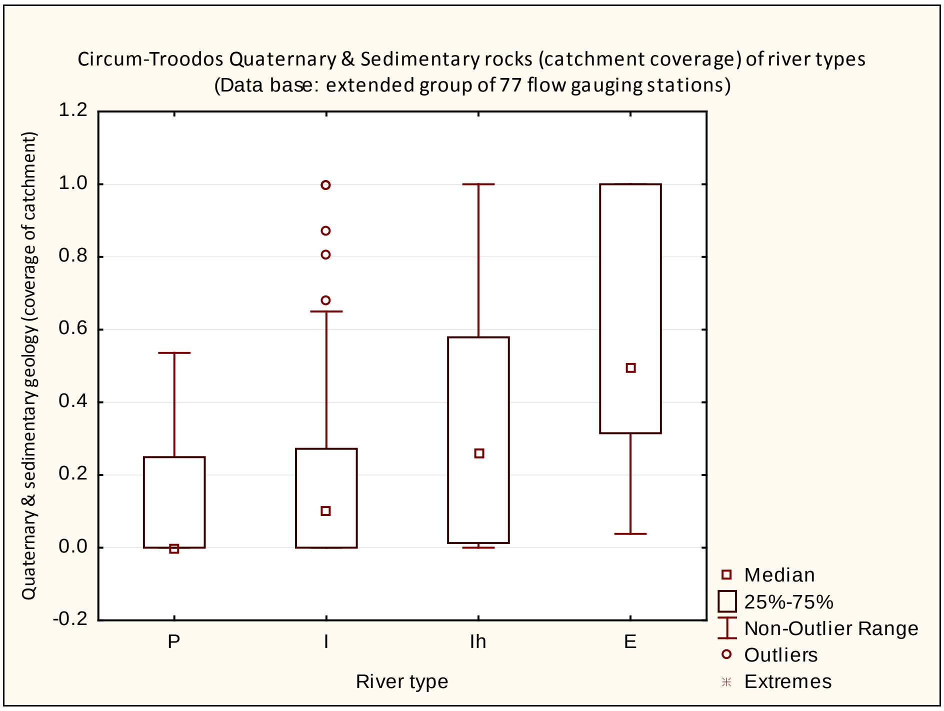

Mean stream slope of river types
(Data base: extended group of 77 flow gauging stations)
Mean stream slope [-]
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
P
I
Ih
E
River type
Median
25%-75%
Non-Outlier Range
Outliers
Extremes

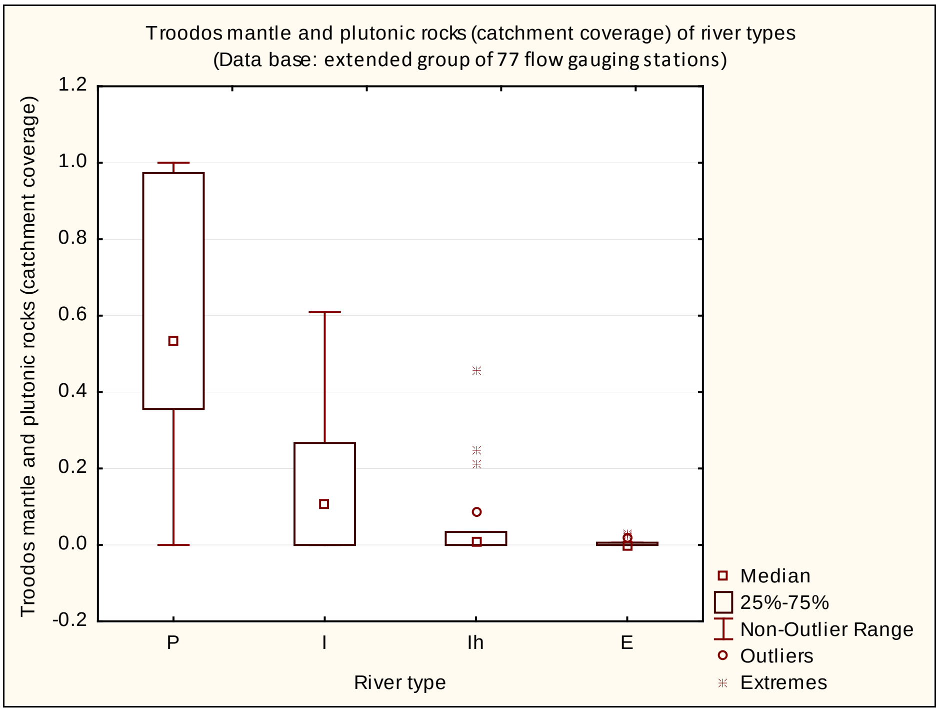

Maximum catchment elevation of river types
(Data base: extended group of 77 flow gauging stations)
Maximum catchment elevation [m amsl]
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
P
I
Ih
E
River type
Median
25%-75%
Non-Outlier Range
Outliers
Extremes


Mean catchment slope of river types
(Data base: extended group of 77 flow gauging stations)
Mean catchment slope [degrees]
35
30
25
20
15
10
5
0
-5
P
I
Ih
E
River type
Median
25%-75%
Non-Outlier Range
Outliers
Extremes


Circum-Troodos sedimentary rocks (catchment coverage) of river types
(Data base: extended group of 77 flow gauging stations)
Circum-Troodos sedimentary rocks (coverage of catchment)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
P
I
Ih
E
River type
Median
25%-75%
Non-Outlier Range
Outliers
Extremes


Troodos Ophiolite rocks (catchment coverage) of river types
(Data base: extended group of 77 flow gauging stations)
Troodos Ophiolite rocks (coverage of catchment)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
P
I
Ih
E
River type
Median
25%-75%
Non-Outlier Range
Outliers
Extremes

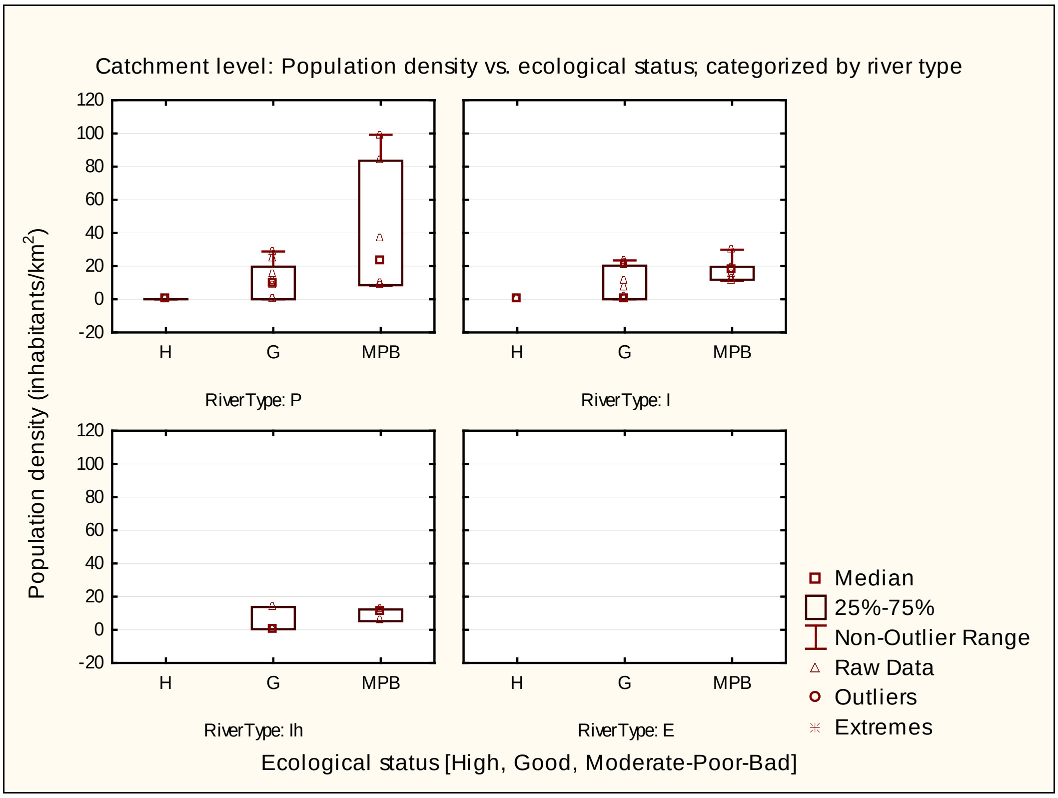

Circum-Troodos Quaternary & Sedimentary rocks (catchment coverage) of river types
(Data base: extended group of 77 flow gauging stations)
Quaternary & sedimentary geology (coverage of catchment)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
P
I
Ih
E
River type
Median
25%-75%
Non-Outlier Range
Outliers
Extremes

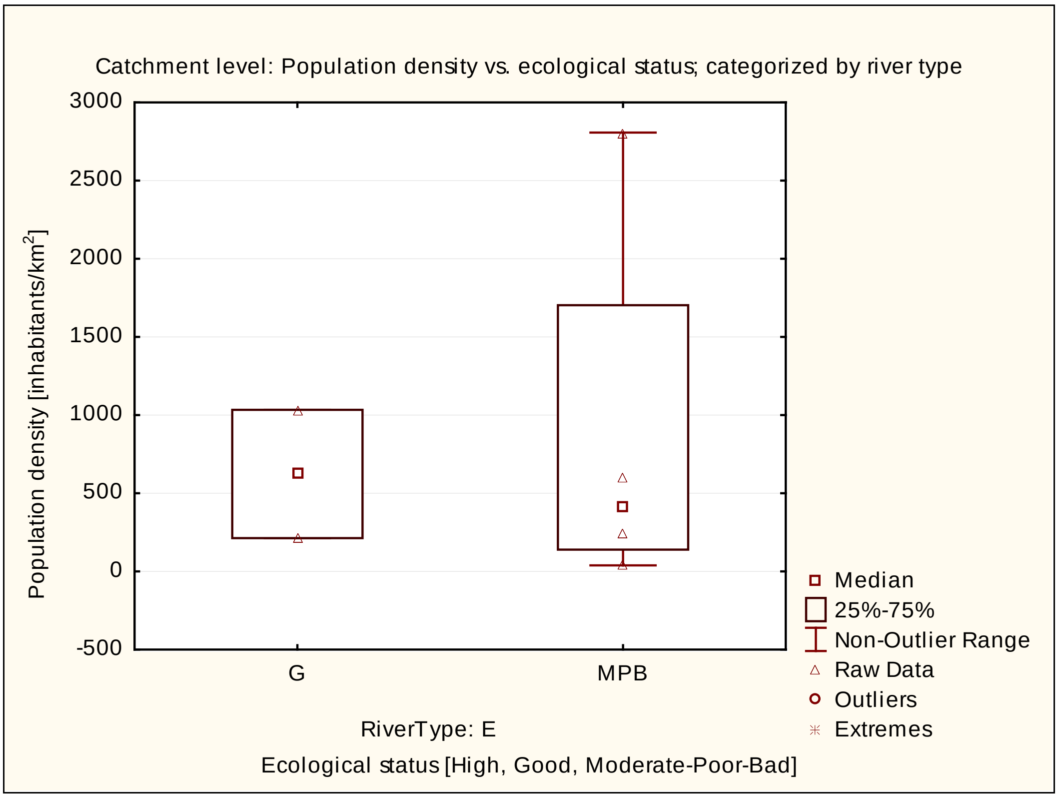

Troodos mantle and plutonic rocks (catchment coverage) of river types
(Data base: extended group of 77 flow gauging stations)
Troodos mantle and plutonic rocks (catchment coverage)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
P
I
Ih
E
River type
Median
25%-75%
Non-Outlier Range
Outliers
Extremes

Appendix 3 Graphs of pressure characteristics vs. ecological status, categorized by river type

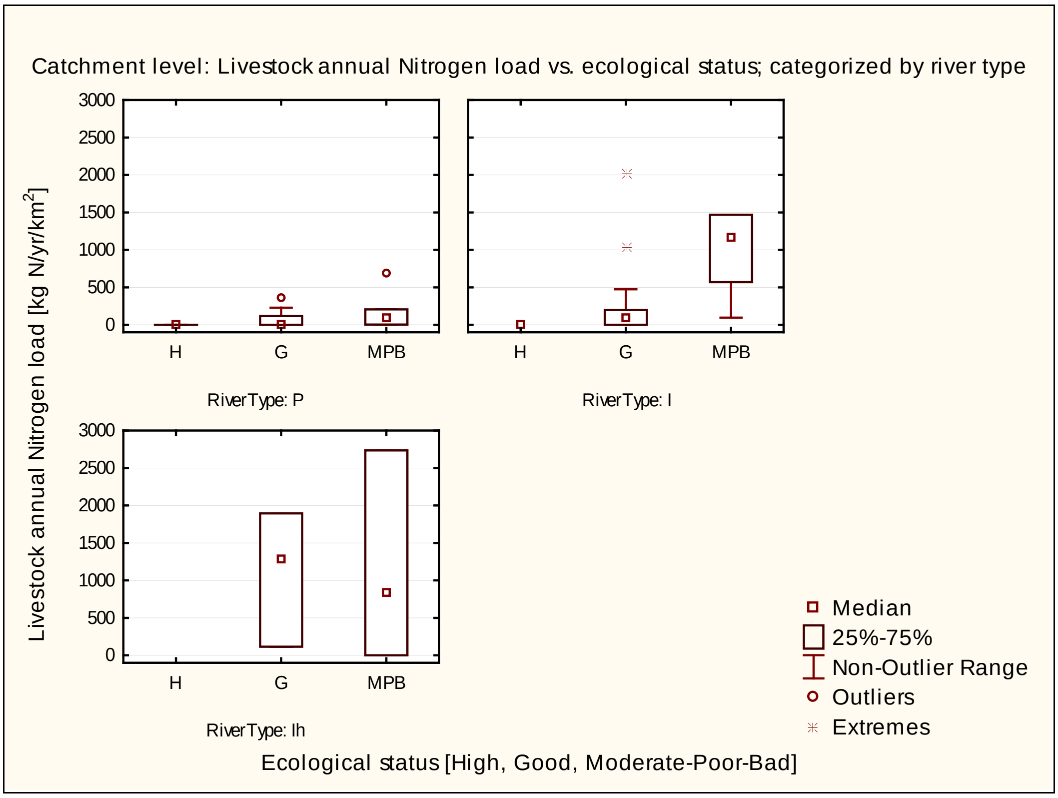
Note: Graphs with inconclusive content are not shown.

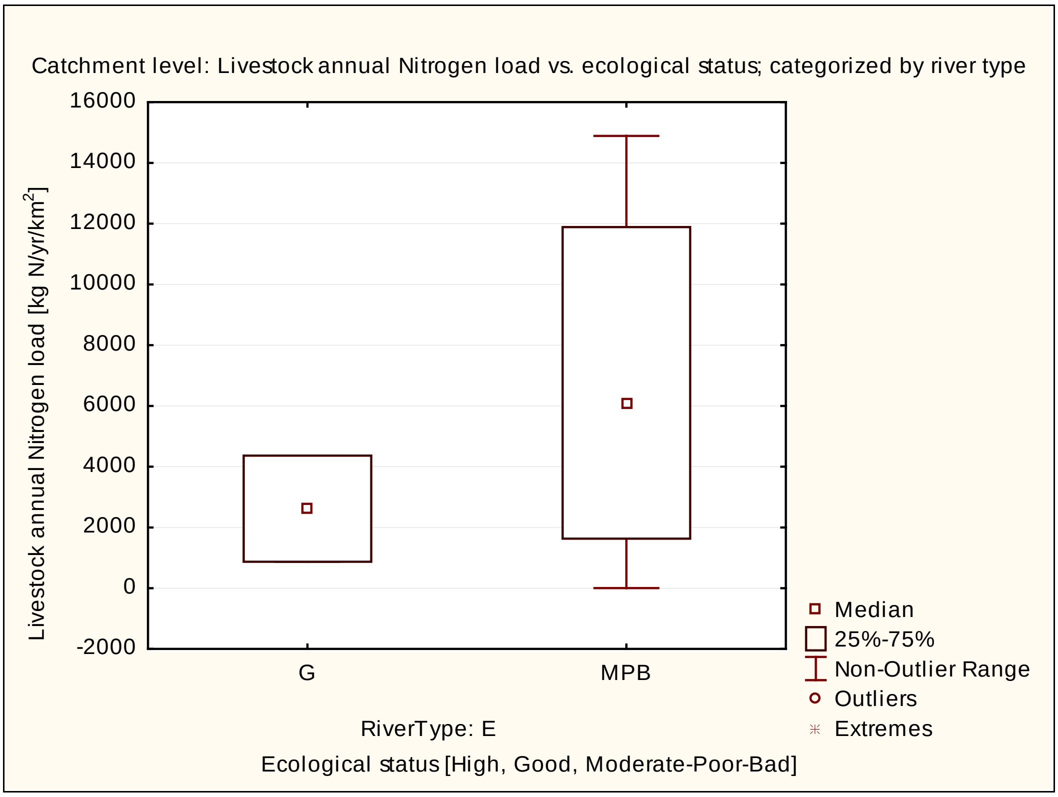
CATCHMENT LEVEL: PRESSURE CHARACTERISTIC: POPULATION DENSITY



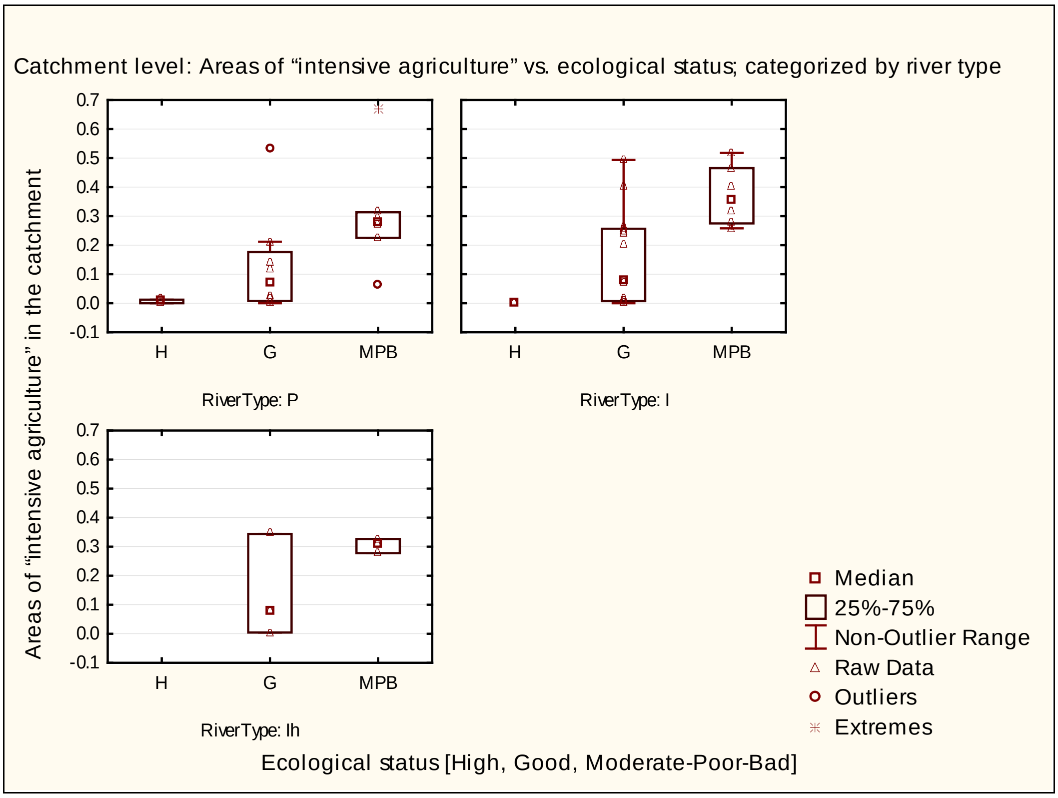


CATCHMENT LEVEL: PRESSURE CHARACTERISTIC: LIVESTOCK N LOAD



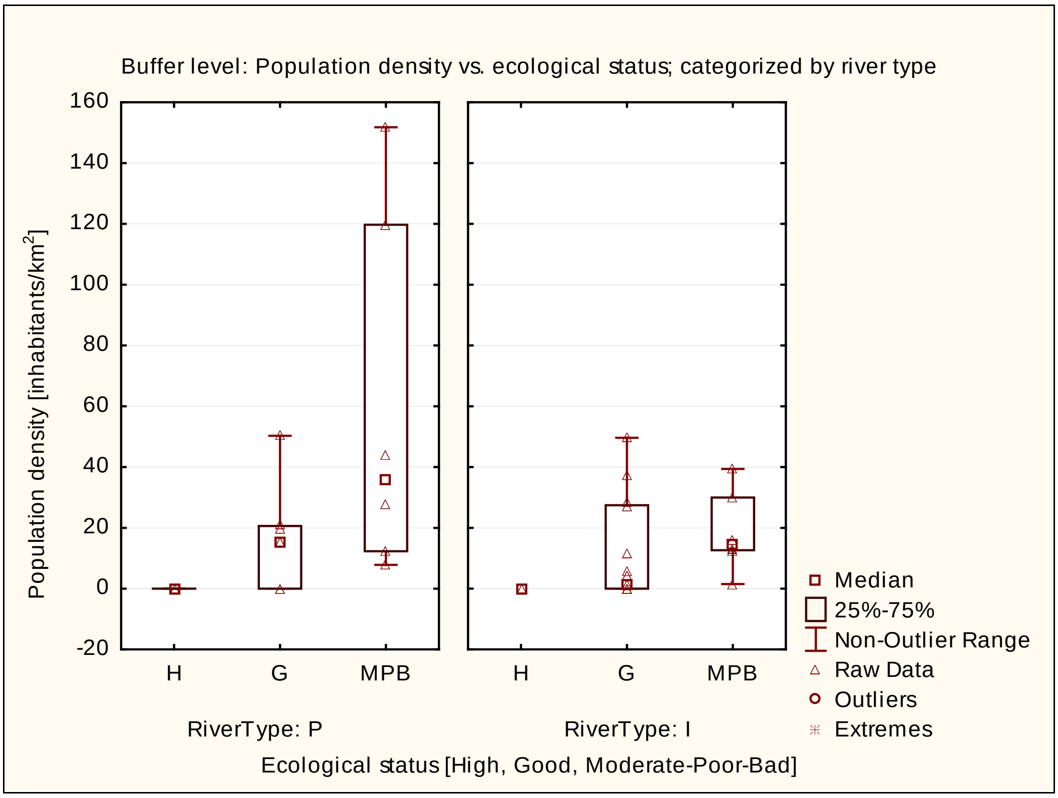


CATCHMENT LEVEL: PRESSURE CHARACTERISTIC: AREAS OF "INTENSIVE AGRICULTURE"



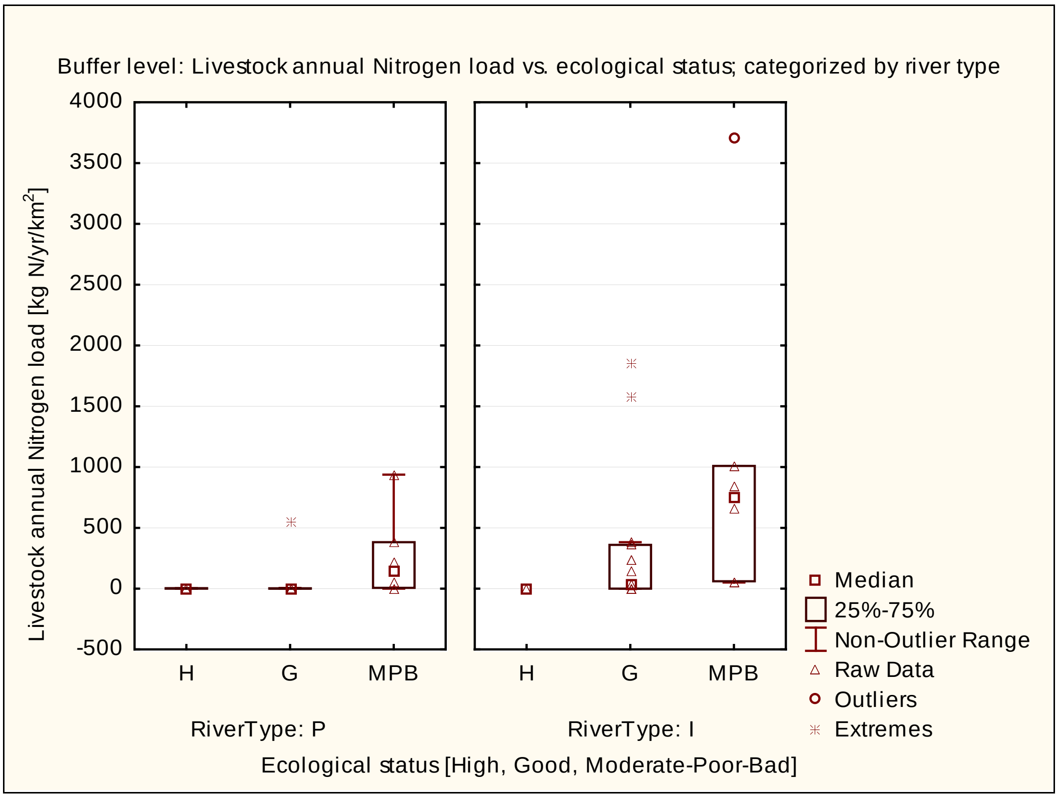
E type is inconclusive and thus not shown

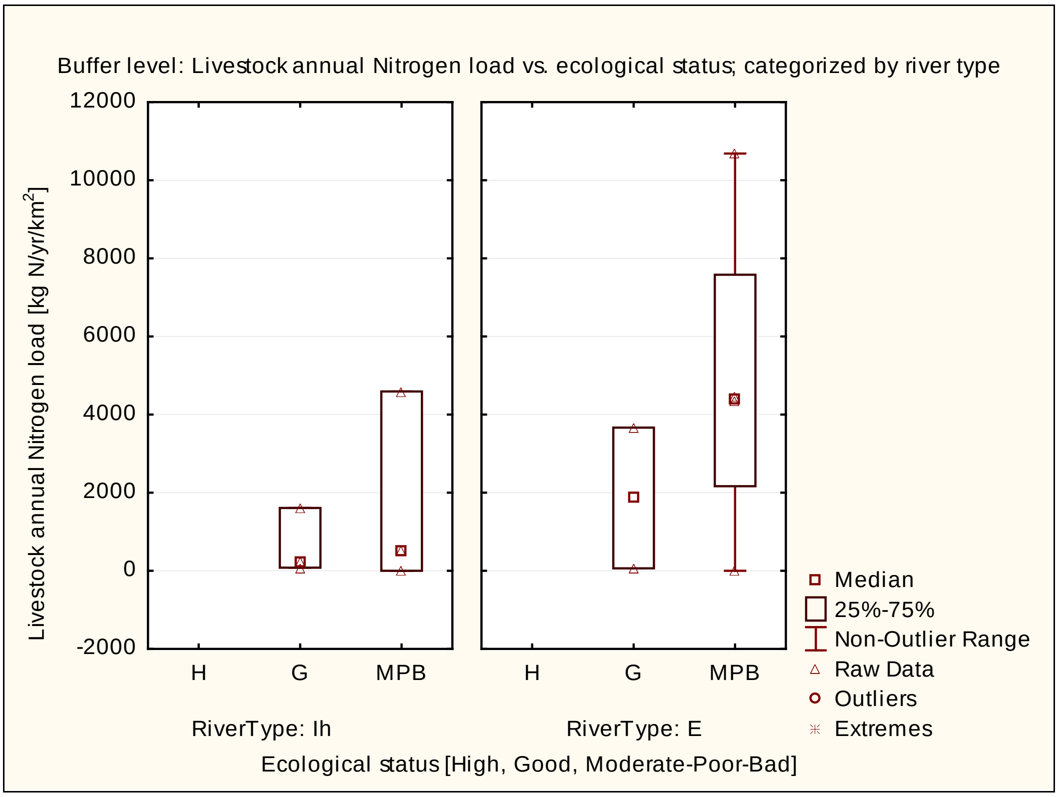
BUFFER LEVEL: PRESSURE CHARACTERISTIC: POPULATION DENSITY



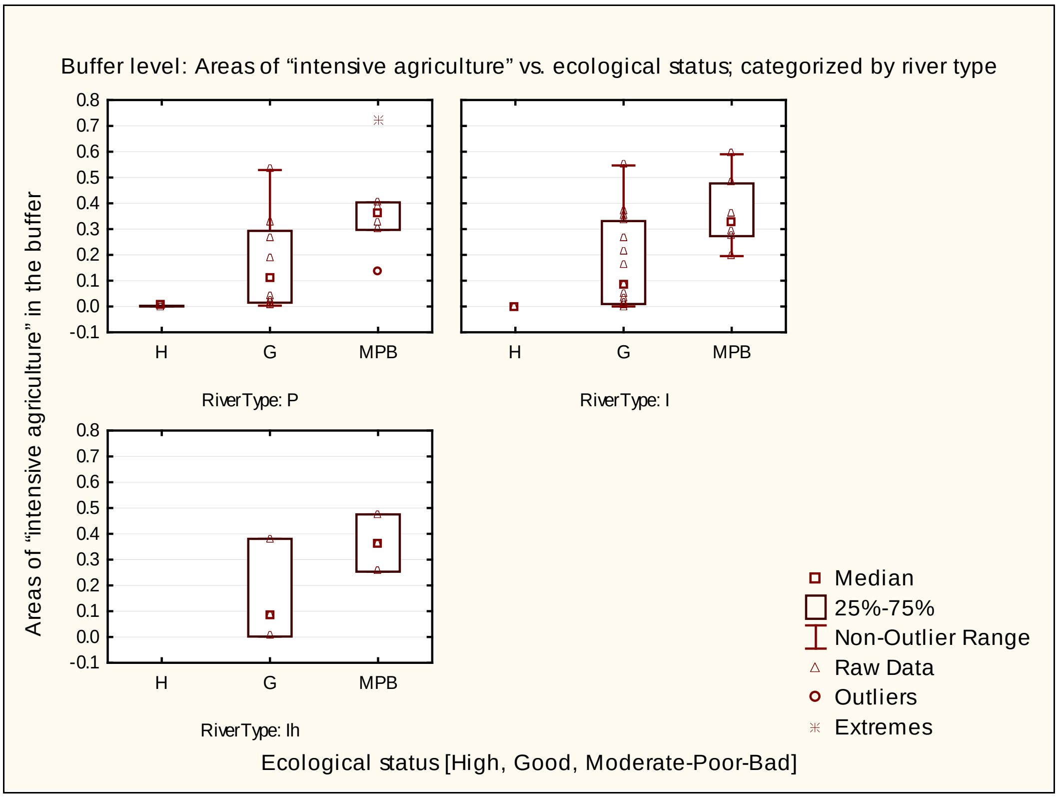
Ih and E types are inconclusive and thus not shown

BUFFER LEVEL: PRESSURE CHARACTERISTIC: LIVESTOCK N LOAD



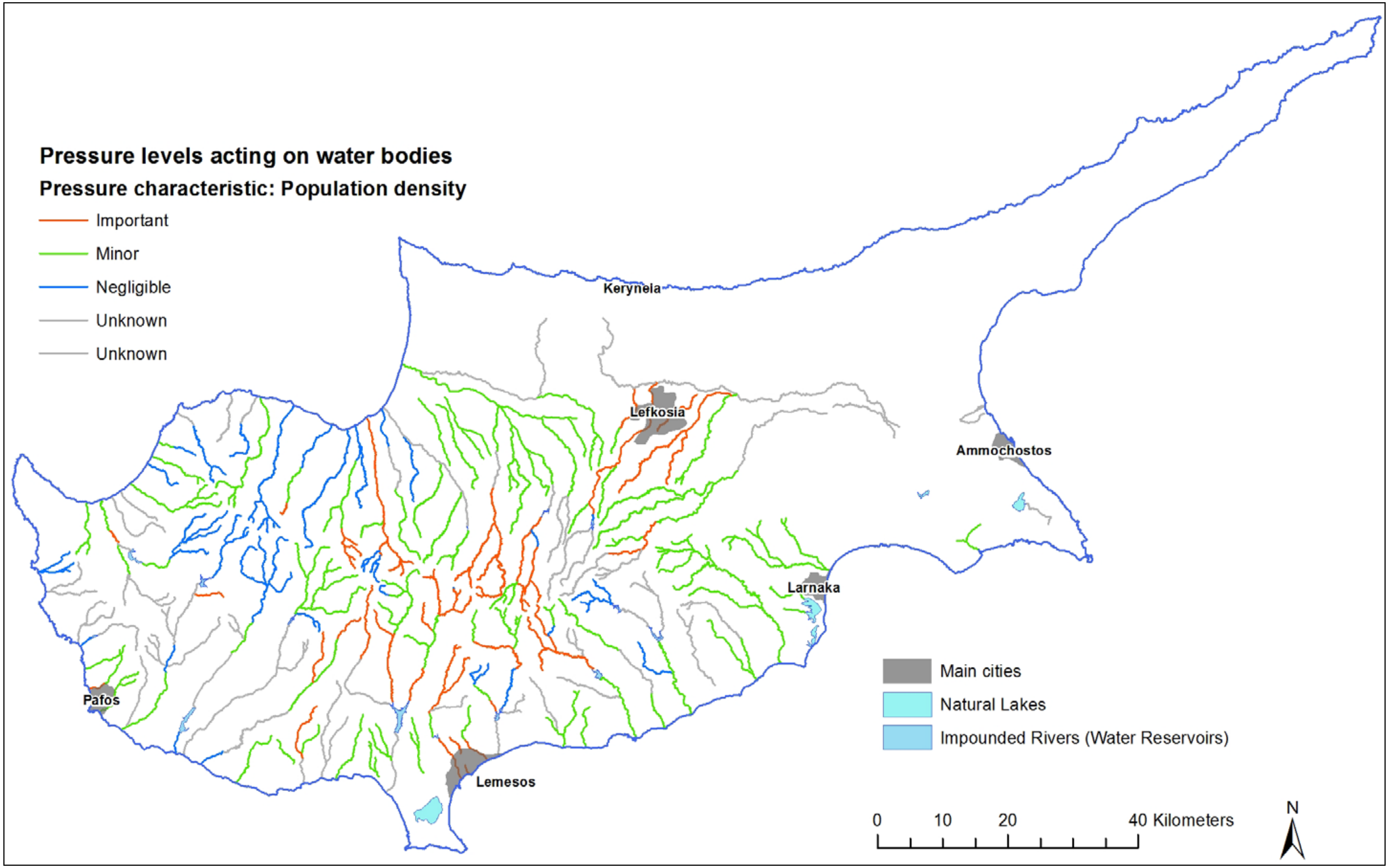


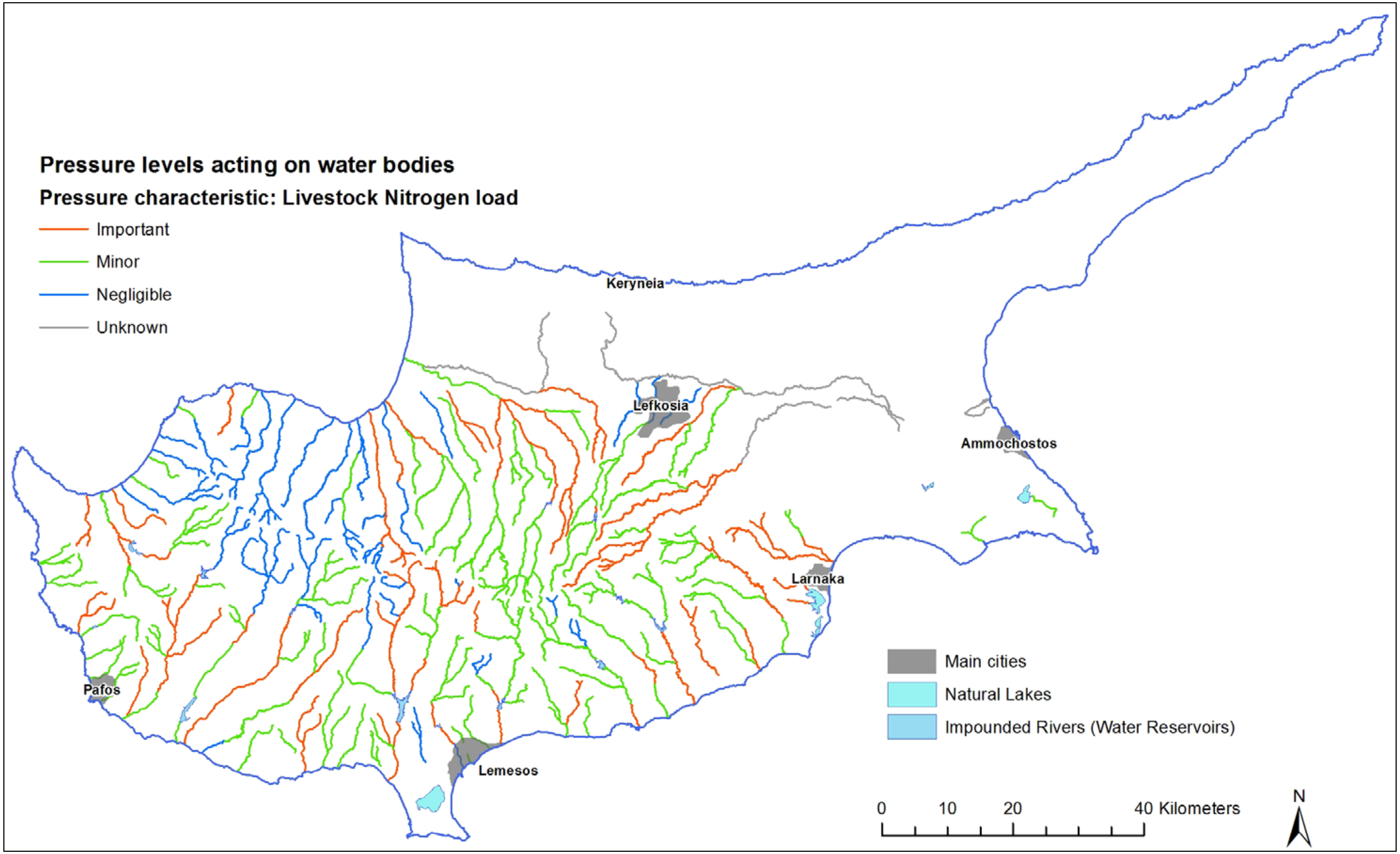
CATCHMENT LEVEL: PRESSURE CHARACTERISTIC: AREAS OF “INTENSIVE AGRICULTURE”

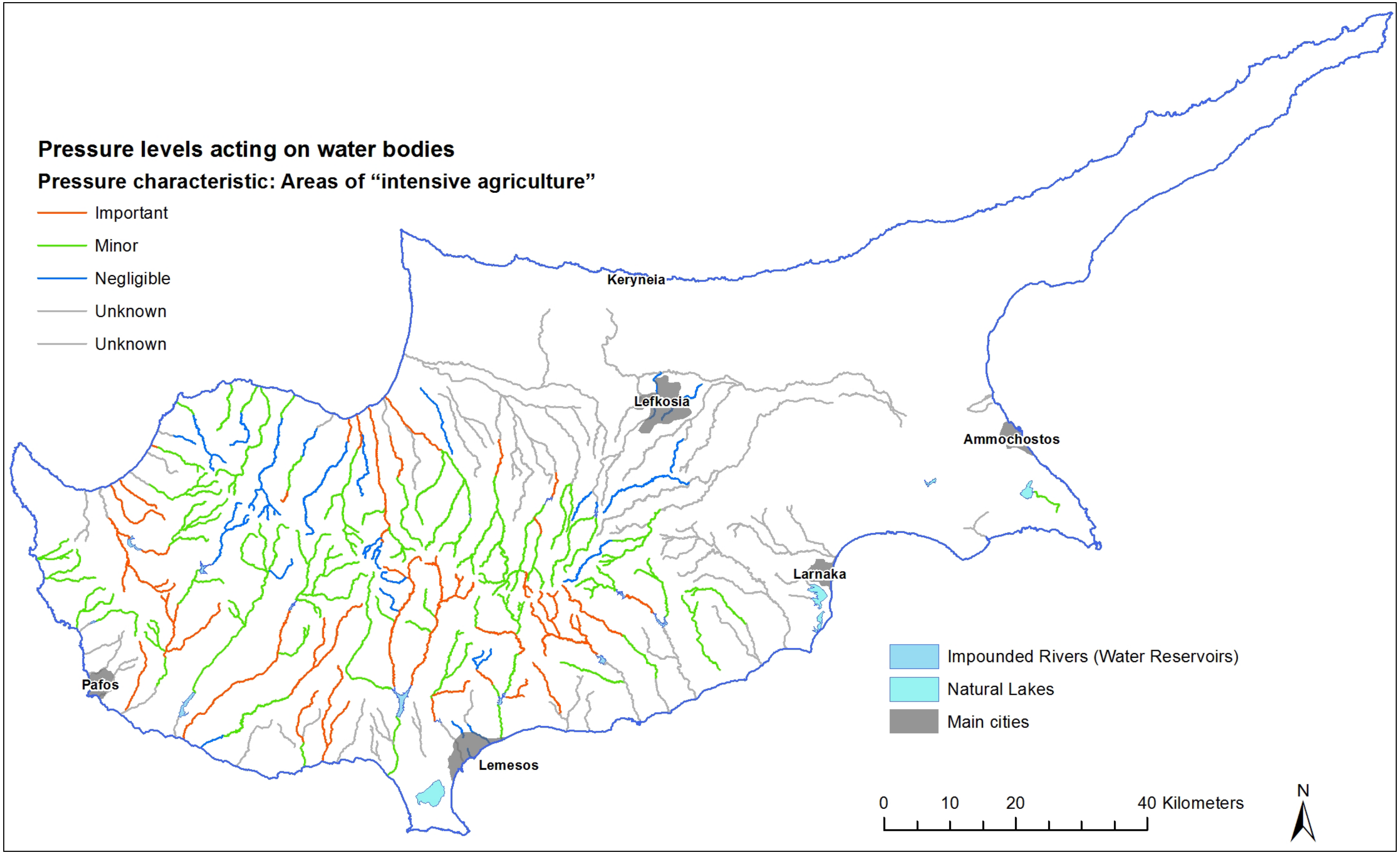


E type is inconclusive and thus not shown

Appendix 4 Maps showing the pressure levels acting on water bodies.




Pressure levels acting on water bodies
Pressure characteristic: Livestock Nitrogen load
Important
Minor
Negligible
Unknown
Keryneia
Lefkosia
Ammochostos
Larnaka
Pafos
Lemesos
Main cities
Natural Lakes
Impounded Rivers (Water Reservoirs)
0
10
20
40 Kilometers
N


Pressure levels acting on water bodies
Pressure characteristic: Areas of “intensive agriculture”
Important
Minor
Negligible
Unknown
Unknown
Keryneia
Lefkosia
Ammochostos
Larnaka
Pafos
Lemesos
Impounded Rivers (Water Reservoirs)
Natural Lakes
Main cities
0
10
20
40 Kilometers
N

Appendix 5 Master code list, as it was used for the coding of the stakeholder consultation sessions transcripts

Master code list of Aquad7 project "DProf_v4"

/$ALL
/$DFMR _xx
/$EnvDep _xx
/$EnvDep _xx
/$GD
/$GF _xx
/$IACO _xx
/$IACO _xx
/$IACO _xx
/$SGL _xx
/$WDD _xx
/$WDD _xx
/$WDD _xx
/$WDD _xx
/$WDD _xx
/$WDD _xx
/$WDD _xx
/$WDD _xx
/$WDD _xx
/$WDD _xx
/$WDD _xx
/1st_session_20131108
/2nd_session_20131122
/3rd_session_20140307
/4th_session_20140328
/5th_session_20141103
/WDD_and_stakeholders
/WDD_internal
/WDD_stakeholders_public
10km2_threshold
A_RQ_benefit
A_RQ_feedback
A_RQ_no_change_no_impact
A_RQ_potnegeffect
A_RQ_requesting_assessment_of_impact
abstractions
achieving_environmental_objectives

acknowledges_improvements_through_Dprof_proposal
acknowledges_quality_of_work
acknowledging_mistakes
acknowledging_researcher_expertise
ACTION_joining_leaving_session
advocating_thorough_monitoring
ambiguity
arguments_for_explanation_to_EU
asking_for_participants_view
avoid_commitment

B1_RivNetReview
B2_typology
B3_types_to_reaches
B4_WB_delineation
B5_grouping
B6_WB_Codes
being_angry
being_confident
being_not_convinced
believing_something_is_wrong
benefit
bibliography
biota
change
clarification_of_methodology
COMM_compliance
comparing_2005_DProf_riv_network
comparing_2005_DProf_typology
comparing_2005_DProf_WB_codes
comparing_2005_DProf_WB_network
comparing_with_RBMP1_approach
comprehension
concern
conflict
consent
continuity
cooperation
coordination
cost
Dam
de-designation
describing_2005_riv_network
describing_perspective
difficult_work
digesting_previous_deliberation
dilemma
disagreement_on_potenial_benefits
disagreement_with_Dprof_approach
Disbelief_Unglauben
disillusionment
dissent
does_not_exist
doubt
DProf_outcome_use_in_WDD_work
DProf_progress
DProf_proposal
DProf_proposal_is_midway_solution
DProf_scope
drawing_conclusions

drought
dubious_input_data
EFlows
ephemeral_streams
expert_judgement
explaining_methodology
explaining_other
expressing_interest
flexibility
floods
future_changes
future_work
Gaps
giving_example
giving_instructions
headwaters
Hiding_the_reality
highlighting_problem
HMWB
IA_accusation
IA_affirmation
IA_agreement
IA_Agreement_with_DProf_Proposal
IA_all_shouting_at_same_time
IA_answer
IA_continuation
IA_objection
IA_question
IA_question_solved
IA_supporting_previous_own_argument
impacted_streams
Impossible_situation
include_streams
incomprehension
increase_become_more
Incredulity_Unglaeubigkeit
indicating_importance
indicating_pitfalls_of_alternative_approach
input_data
input_data_lack_of
input_of_local_knowledge
intercalibration
interest_in_method_justification
irony
is_amused
Iterative_loop
justifying_methodology
lack_of_ecological_value
lack_of_justification
lack_of_knowledge
leaving_decision_to_participant
legislation
limitation
limited_consultation
lowland_vs_highland
makes_no_sense
management
Maps
MC_Descrptiv_Cd_Topics
MC_IA_asking_question
MC_remove_reduce_etc
measurements
method_tool_works_well
methodology
monitoring
monitoring_chemical
monitoring_extent_of
multi_pressure_situation
national_Law_ vs_WFD
nescience_of_WFD_regulations
no_impact_on_work
No_interest_for_issues_of_other_Depts
no_problems
not_considered_in_DProf_work
NOT_extending_network
not_much_different
Number_of_WBs
obligation
occupied_area
open_for_discussion
open_to_suggested_change
Opening_up_previous_agreements
other_countries
outcome_provision_to_colleagues
participants_disagree_between_themselves
pinpointing_valuable_results
PoM
postponing_decision
prefering_to_exclude_rivers
preferring_less_WBs
preferring_narrow_WFD_ONLY_approach
prefers_low_effort
pressures
promoting_non_generalized_approach
protected_areas
providing_details_results
providing_intermediate_results
public_consultation
QUOTE
RBMP
reduce
reduce vs. decrease rivers
reduce_monitoring
reduce_rivers
relation_to_RBMP1
remove_rivers
reporting_information_in_report
requesting_arguments_reasons

requesting_details
respect_for_COMM
result
river
river_bed_existence
rivers_to_WBs
saltlakes
significance_for_ecosystem
stakeholders
status_assessment
stream_protection
streams_addition
subtypes
suggesting_alternative_approach
suggesting_change
suitability_for_local_situation
supporting_denser_river_network
surprise
surprised_by_result
target
Tearing_down_dam
tech_research_question
technical_details
time
timeseries
tributaries
typology
underestimating_work_amount
unknown_outcome
unnecessary_discussion
unresolved_issue
unwilling_to_discuss_local_details
upstream_vs_downstream_population
urbanized_areas
Use_is_very_important
use_of_reservoir_water
vicious_cycle
water_abstraction
WB_Codes
WB_grouping
WB_identification vs pressures
WB_level_vs_station_level
WB_Network
WB_removal
WB_scope_of
WB_splitting
WB_vs_entire_catchment
WFD
WFD vs floods
WFD vs Nature Directives
WFD_Art5_review
WFD_NatureDirectives_Co_Management
willingness
work load

Appendix 6 Tables of participants of stakeholder sessions

Stakeholder consultation session #1

AA	Department, organization	Participants
1	Water Development Department	Executive Engineer #1
2	Water Development Department	Executive Engineer#2
3	Water Development Department	Hydrologist #1
4	Water Development Department	Hydrologist #2
5	Water Development Department	Senior Executive Engineer #1
6	Water Development Department	Senior Hydrologist #1
7	Water Development Department	Senior Hydrologist #2

Stakeholder consultation session #2

AA	Department, organization	Participants
1	Department of Agriculture	Agriculture Officer #1
2	Department of Agriculture	Agriculture Officer #2
3	Department of Fisheries and Marine Research	Fisheries and Marine Research Officer
4	Department of the Environment	Environment Officer #1
5	Geological Survey Department	Hydrogeologist #1
6	Water Development Department	Director
7	Water Development Department	Executive Engineer #3
8	Water Development Department	Senior Executive Engineer #1
9	Water Development Department	Senior Executive Engineer #2
10	Water Development Department	Senior Executive Engineer #3
11	Water Development Department	Senior Hydrologist #1
12	Water Development Department	Senior Hydrologist #2
13	Water Development Department	Technician #1
15	WDD contractor (environmental consultancy firm)	Consultant #1
16	WDD contractor (environmental consultancy firm)	Consultant #2

Stakeholder consultation session #3

AA	Department, organization	Participants
1	Water Development Department	Engineer Technician #2
2	Water Development Department	Executive Engineer #1
3	Water Development Department	Executive Engineer#2
4	Water Development Department	Hydrologist #2
5	Water Development Department	Senior Executive Engineer #1
6	Water Development Department	Senior Executive Engineer #3
7	Water Development Department	Senior Hydrologist #1
8	Water Development Department	Senior Hydrologist #2
9	Water Development Department	Technician #3
10	Water Development Department	Technician #4
11	Water Development Department	Technician #5
12	WDD contractor (environmental consultancy firm)	Consultant #1
13	WDD contractor (environmental consultancy firm)	Consultant #2

Stakeholder consultation session #4

AA	Department, organization	Participants
1	Department of Fisheries and Marine Research	Senior Fisheries and Marine Research Officer
2	Department of Forests	Forestry Officer #1
3	Department of Forests	Forestry Officer #2
4	Department of the Environment	Environment Officer #2
5	Department of the Environment	Environment Officer #3
6	Department of the Environment	Senior Environment Officer
7	Game Service	Game Service Officer
8	Geological Survey Department	Hydrogeologist#2
9	State General Laboratory	Chemist #1
10	State General Laboratory	Chemist #2
11	Water Development Department	Deputy Director
12	Water Development Department	Engineer Technician #1
13	Water Development Department	Engineer Technician #2
14	Water Development Department	Executive Engineer #1
15	Water Development Department	Executive Engineer#2
16	Water Development Department	Hydrologist #2
17	Water Development Department	Hydrologist #3
18	Water Development Department	Hydrologist #4
19	Water Development Department	Senior Executive Engineer #1
20	Water Development Department	Senior Hydrologist #1
21	Water Development Department	Senior Hydrologist #2
22	Water Development Department	Technician #2
23	Water Development Department	Technician #3
24	Water Development Department	Technician #4
25	WDD contractor (environmental consultancy firm)	Consultant #1
26	WDD contractor (environmental consultancy firm)	Consultant #2
27	WDD contractor (environmental consultancy firm)	Consultant #3
28	WDD contractor (environmental consultancy firm)	Consultant #4

Stakeholder consultation session #5

AA	Department, organization	Participants
1	Ag. Athanasios Municipality	Technician
2	Aglantzia Municipality	Deputy Municipal Engineer
3	Agricultural Research Institute	Agricultural Research Officer
4	Ammochostos District Administration	Engineer Technician
5	Ammochostos District Administration	Secretarial Officer
6	BirdLife Cyprus Environmental NGO	Executive Director
7	Commerce and Industry Chamber Ammochostos	Secretary/Director
8	Communities Union Cyprus	President
9	Consultancy company	Director Environment Section
10	Consultancy firm	Consultant #3
11	Cyprus Tourism Organization	Technician
12	Cyprus Tourism Organization	Tourism Officer Class A
13	Department of Agriculture	Agriculture Officer #3
14	Department of Agriculture	Agriculture Officer #4
15	Department of Agriculture	Agriculture Officer #5
16	Department of Agriculture	Deputy District Agricultural Officer
17	Department of Agriculture	Director
18	Department of Agriculture	Senior Agricultural Officer
19	Department of Fisheries and Marine Research	Fisheries and Marine Research Officer
20	Department of the Environment	Environment Officer #1
21	Department of the Environment	Environment Officer #4
22	Department of the Environment	Senior Environment Officer
23	Dept. of Forests	Forestry Officer #3
24	Dept. of Forests	Forestry Officer #4
25	Employers and Industrialists Federation	Industry Officer
26	ETEK	Representative
27	Forestry College	Forestry College representative
28	Friends of Akamas Environmental Organization*	Representative
29	Geological Survey Dept.	Geology Officer
30	Geological Survey Dept.	Hydrogeologist #1
31	Geological Survey Dept.	Hydrogeologist #2
32	Land Consolidation Dept.	Land Consolidation Officer
33	Land Development Company	Health & Safety Env. Officer
34	Larnaca Sewerage Board	Chemist
35	Larnaca Water Board	Technician
36	Latsia Municipality	Municipal Secretary
37	Latsia Municipality	Technician
38	Latsia Municipality	Technician
39	Limassol Sewerage Board	General Director
40	Limassol Sewerage Board	Senior Technician
41	Limassol Water Board	Deputy Head of Technical Dept.
42	Limassol Water Board	Internal Auditor
43	Meteorological Service	Director
45	Mines Service	Mines Officer
46	Nea Agrotiki Movement Agricultural Organization	Vice-president
47	Nicosia District Administration	Deputy District Officer
48	Nicosia Sewerage Board	Executive Engineer
49	Nicosia Water Board	

AA	Department, organization	Participants
50	Panagrotikos Association Cyprus Agricultural Organization	General Secretary
51	Paphos Sewerage Board	Executive Engineer
52	State General Laboratory	Chemist 1st Class
53	State General Laboratory	Director
54	State General Laboratory	Laboratory Inspector
55	State General Laboratory	Senior Chemist
56	Strovolos Municipality	Head of Environm. Development Dept.
57	Town Planning and Housing Dept.	Senior Town Planning and Housing Officer
58	Town Planning and Housing Dept.	Town Planning and Housing Officer
59	Union of Environmental Organizations (Cyprus)*	Representative
60	Water Development Department	District Engineer
61	Water Development Department	Engineer Technician #3
62	Water Development Department	Ex-Director
63	Water Development Department	Executive Engineer #1
64	Water Development Department	Executive Engineer #2
65	Water Development Department	Executive Engineer #3
66	Water Development Department	Executive Engineer #4
67	Water Development Department	Executive Engineer #5
68	Water Development Department	Executive Engineer #6
69	Water Development Department	Executive Engineer #7
70	Water Development Department	Executive Engineer #8
71	Water Development Department	Executive Engineer #9
72	Water Development Department	Hydrologist #3
73	Water Development Department	Public Health Engineer
74	Water Development Department	Public Health Engineer
75	Water Development Department	Secretarial Officer
76	Water Development Department	Senior Engineer Technician
77	Water Development Department	Senior Executive Engineer #1
78	Water Development Department	Senior Executive Engineer #2
79	Water Development Department	Senior Executive Engineer #3
80	Water Development Department	Senior Executive Engineer #4
81	Water Development Department	Senior Executive Engineer #5
82	Water Development Department	Senior Hydrologist #1
83	Water Development Department	Technician
84	Water Development Department	Technician #1
85	Water Development Department	Technician #5

*) Not mentioned on the official WDD participants lists (Kaimaki, 2014) but were recorded on the session's audio tape.

Appendix 7 Communications with responsible authorities in Spain and Malta

(17 pages: pages 1-4: communication with Spain; pages 5-17: communication with Malta)

Gerald Dörflinger

From: Muñoz Briongos, Belén <BMBriongos@magrama.es>
Sent: 03 October 2014 10:36
To: 'gdorflinger@wdd.moa.gov.cy'
Cc: Carrasco Pinto, Irene
Subject: Grouping

Follow Up Flag: Follow up
Due By: 09 October 2014 12:00
Flag Status: Flagged

Dear Gerald,

I am Belén Muñoz from the Ministry of Agriculture, Food and Environment. Irene gave me your contact. At the moment she is in charge of other topics.
We met some years ago in a MED Lake GIG meeting. I was working during that time in CEDEX.
Last ECOSTAT I asked you with Maria Helena Alves about how Cyprus solved the problem of not sampling every WB
I read in a report of the European Commission "COMMISSION STAFF WORKING DOCUMENT European Overview (1/2) Accompanying the document REPORT FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL on the Implementation of the Water Framework Directive (2000/60/EC) River Basin Management Plans" that Cyprus and Ireland (page 105) made a good job on this topic. Could you send me some information about how Cyprus has done it?
We would like to know as much as possible because we would like to do something similar and we would like to know if we have enough data for doing it.
Thank you very much. See you at the next ECOSTAT meeting in London!

Kindly regards,

Belén

Belén Muñoz Briongos
Subdirección General de Planificación y Uso Sostenible del Agua
Dirección General del Agua
Plaza San Juan de la Cruz, s/n, 2ª planta, Despacho B 203
28071 Madrid
Teléfono: 915975437
BMBriongos@magrama.es

Gerald Dörflinger

From:	Gerald Dörflinger <gdorflinger@wdd.moa.gov.cy>
Sent:	17 October 2014 14:10
To:	'Muñoz Briongos, Belén'
Cc:	'Carrasco Pinto, Irene'
Subject:	RE: Grouping
Attachments:	CY_Art5_review_2013_RivWBgrouping.pdf

WDD file no.: 4.2.2.6, 5.22.001

Dear Belen,

I finally managed to put together some information on what I have done for the grouping of river water bodies. I attach a presentation on the topic that I have given at our Department, and in the following is a description of what was done.

Please note that the grouping I describe is for the 2nd RBMP. River water bodies had also been grouped for the 1st RBMP and this former grouping system had been used for the 1st RBMP; however, the old groups were found not to work well and it was decided, in the course of the Art. 5 review, to attempt a new grouping system, which is described below:

The general idea was to group the river water bodies into groups of similar pressure levels (of course keeping the river types separate). Thus we would have groups of water bodies with similar pressure within each river type, and we would be able to predict and assign water body ecological status to the WBs that are not being monitored, using the data from the monitoring stations within each group. We paid most attention to the definition of the pressure level that corresponds to the critical G/M boundary, because we must be able to separate the WBs achieving the WFD objectives from the WBs failing the objectives, even for those WBs where the status is assigned by grouping.

First I analyzed our monitoring and water status data in order to identify those QEs leading to failure to achieve good status. From the QEs leading to failure to achieve good status, I concluded on the pressures that most probably cause the impacts on the QEs (i.e. more or less the “significant” pressures mentioned in the WFD), and then I tried to find proxies with available data for these pressures. This is one of the crucial issues: After understanding which pressures are “significant”, you need to find data to quantify these pressures! For our case here in Cyprus, I had concluded on the following pressures and proxies:

1. Urbanization -> Population density
2. Livestock -> Livestock annual N load
3. Agriculture -> Areas of “intensive agriculture”, largely irrigated (based on selected Corine 2006 categories)

These may seem a bit crude, but I tried to keep things simple and check whether I could get pressure-impact relationships with these crude parameters. Also, we must keep in mind the purpose of the exercise: the grouping of water bodies and not the Art. 5 review of pressures and determination of significant pressures – the latter was done separately (and at a later stage) by a consultant with much more detail.

The above proxy pressures were then quantified on the WB level i.e. for each water body and on two spatial levels: WB catchment and WB buffer; I decided later which spatial level gave the better pressure/impact-status relationship and discarded the other from the analysis.

The quantified proxy pressures of the monitored WBs were then related to the corresponding water status; this was done using boxplots and of course separately for each river type. From the boxplots we could then identify thresholds of the proxy pressures that correspond to the H/G and the G/MPB boundary (I had lumped the moderate, poor and bad classes together into the MPB class). According to the thresholds, each water body was classified into one of three categories of pressure&impact: none, minor or important, corresponding to the high, good and the lumped moderate/poor/bad status classes. In general this worked well for perennial and “normal” intermittent rivers (i.e. with a dry period of 3-5 months). However, this was not possible for all pressures and river types, mainly due to lack of data; still, I think that the high variability and complexity of processes in dry intermittent (approx. 6-7.5 months dry) and in ephemeral rivers is also increasing the difficulty to determine pressure-impact-status relationships.

The next step was to assign a numerical score to each of the three categories of pressure&impact (none, minor, important), and by averaging the scores of the three pressures of each WB, a “global pressure index” was calculated for each WB. Now this “global pressure index” was related to the corresponding water status using boxplots, and thresholds of the “global pressure index” that correspond to the H/G and the G/MPB boundary were identified for the perennial and “normal” intermittent river types. For the dry intermittent and ephemeral rivers there was not enough data, and thresholds were set manually based on the available data and expert judgement.

The proxy pressures had been quantified for all WBs and by applying the above procedure and thresholds to them, all WBs were classified into pressure&impact groups of none, minor and important, separately for each of the 4 river type thus yielding 3 x 4 = 12 groups.

Finally, within each of the 12 groups, we used the monitoring stations located within each group (i.e. stations on WBs included within each group) to calculate the ecological status using all available QEs, and this ecological status per group was then assigned to all unmonitored WBs of the group.

The reduced reliability of the water status assigned by grouping was taken into account when we assigned confidence and precision to the WBs. That way, we can focus our PoM to the WBs with the highest confidence that they are really not achieving the environmental objectives.

In general, I would think that the procedure I used worked rather well because in Cyprus we are dealing with four river types only, the major pressures are few (though significant) and the island itself is rather small. In a very simplistic way, one could say Cyprus consists of one central mountain range with the typical downstream succession of Mediterranean river types towards the sea on more or less all sides (perennial-intermittent-ephemeral); thus, there aren’t many different regions that would create many different pressure situations. In a large country, it may be helpful to work on distinct regions with distinct river types.

Please also keep in mind that in our rivers there is no native fish, so we do not use the BQE for status assessment – if you use fish, I suppose your pressure-impact-status relationships may become much more complex.

Please feel free to use the above information and presentation for your Ministry’s purposes, but please do not distribute it wider. It is not published yet, nor officially adopted by Cyprus yet. I am just right now writing a technical report that will be included in the RBMP next year.

I am happy to provide you with more explanations and clarifications if you need them. Please do not hesitate to contact me.

Unfortunately, due to budget constraints, I cannot participate at the ECOSTAT in London. It is a pity because it would have been a perfect opportunity to discuss the grouping issues and probably many other common Mediterranean problems in WFD implementation!

Best regards,
Gerald

****
Gerald Dörflinger
Hydrologist
Div. of Hydrometry

Water Development Dept.
Cyprus
Tel.: +357 22609354
Fax: +357 22609353
Email: gdorflinger@wdd.moa.gov.cy

From: Muñoz Briongos, Belén [mailto:BMBriongos@magrama.es]
Sent: 03 October 2014 10:36
To: 'gdorflinger@wdd.moa.gov.cy'
Cc: Carrasco Pinto, Irene
Subject: Grouping

Dear Gerald,

I am Belén Muñoz from the Ministry of Agriculture, Food and Environment. Irene gave me your contact. At the moment she is in charge of other topics.
We met some years ago in a MED Lake GIG meeting. I was working during that time in CEDEX.
Last ECOSTAT I asked you with Maria Helena Alves about how Cyprus solved the problem of not sampling every WB
I read in a report of the European Commission "COMMISSION STAFF WORKING DOCUMENT European Overview (1/2) Accompanying the document REPORT FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL on the Implementation of the Water Framework Directive (2000/60/EC) River Basin Management Plans" that Cyprus and Ireland (page 105) made a good job on this topic. Could you send me some information about how Cyprus has done it?
We would like to know as much as possible because we would like to do something similar and we would like to know if we have enough data for doing it.
Thank you very much. See you at the next ECOSTAT meeting in London!

Kindly regards,

Belén

Belén Muñoz Briongos
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28071 Madrid
Teléfono: 915975437
BMBriongos@magrama.es

98

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New Memo Forward Reply Edit Delete Go to Copy Into

"Sapiano Manuel at MECW"
<manuel.sapiano@gov.mt>

07/04/2014 13:08

To:<karl.schwaiger@lebensministerium.at>, <bwillocx@environnement.irisnet.be>, <ph.dhondt@vmm.be>, <benoit.tricot@spw.wallonie.be>, <michael.kyramarios@health.fgov.be>, <asenlichev@moew.government.bg>, <stephan.mueller@bafu.admin.ch>, <drazen.kurecic@voda.hr>, <director@wdd.moa.gov.cy>, <karel.vlasak@mzp.cz>, <pavel.puncochar@mze.cz>, <fritz.holzwarth@bmu.bund.de>, <malpe@nst.dk>, <harry.liiv@envir.ee>, <k.triantis@prv.ypeka.gr>, <Lardiles@magrama.es>, <bzn-dgasec@magrama.es>, <saara.back@ymparisto.fi>, <Laurent.Roy@developpement-durable.gouv.fr>, <zoltan.illes@vm.gov.hu>, <Cian.OLionain@environ.ie>, <kristinlinda@umhverfisstofnun.is>, <d.krinickas@am.lt>, <rolands.bebris@varam.gov.lv>, <zorica.djuranovic@mpr.gov.me>, <jan.busstra@minienm.nl>, <Kristin-Thorsrud.Teien@md.dep.no>, <dyrektor@warszawa.rzgw.gov.pl>, <nuno.lacasta@apambiente.pt>, <gheorghe.constantin@mmediu.ro>, <stefan.berggren@regeringskansliet.se>, <dusan.ceresnak@enviro.gov.sk>, <branko.ravnik@gov.si>, <ncicek@ormansu.gov.tr>, <sonia.phippard@DEFRA.gsi.gov.uk>, <Andre.Weidenhaupt@eau.etat.lu>

cc:

bcc:

Subject:Request for Information regarding the designation of small water bodies

ΤΜΗΜΑ ΑΝΑΠΤΥΞΕΩΣ ΥΔΑΤΩΝ
9 APR 2014

8/4

97

Dear Colleagues

Attached please find a request for information in relation to the designation of small surface water bodies.

Your assistance in this regard is highly appreciated.

Rgds

Manuel

Manuel Sapiano
Director
Water Policy Unit

t: +356 22955152 e: manuel.sapiano@gov.mt | www.energy.gov.mt

MINISTRY FOR ENI
THE CONSERVATION (
AUBERGE DE CASTILLE, VALLET

Kindly consider your environmental responsibility before printing this e-mail

Letter_Water_Directors_ Small_Water_Bodies.tif	**Type:** image/tiff **Name:** Letter_Water_Directors_ Small_Water_Bodies.tif

46

MALTA

MINISTERU GĦALL-ENERĠIJA U KONSERVAZZJONI TAL-ILMA

MINISTRY FOR ENERGY AND THE CONSERVATION OF WATER

7 April 2014

Malta's request for information regarding the designation of small waters

Dear Water Director,

Malta is currently carrying out its second inland surface and transitional water characterisation process. All inland surface and transitional waters in the Maltese Islands are tiny with water depths that very rarely exceed 1m during the rainy season. Some of the waters are ephemeral, drying out completely by April or significantly reduced to a trickle until the onset of the following year's rainy period. In order to help Malta compare water bodies in this characterisation process, Malta would like to gather information on whether there are other Member States that have designated any 'Rivers', 'Lakes' and Transitional water bodies of a similar size and nature to those found in the Maltese Islands.

For purposes of comparison the size and water depth ranges are as follows:

Transitional Waters:	Surface Area range	0.01 – 0.03km^2
	Water Depth	0 – 1.9m
Water Courses (Rivers):	Length range	0.6 km^2 - 1.7km^2
	Catchment area	2.4 km^2 – 14 km^2
	Water Depth	0.01m – 0.3m
Standing waters (Lakes):	Surface Area	0.0001km^2 – 0.04km^2
	Catchment area	1km ^{2} – 5 km^2
	Water Depth	0.1m – 1.7m

If there are water bodies designated in your territories of a size comparable to the above ranges, Malta would greatly appreciate if you could provide the contact details of any relevant officials that may be able to assist Malta in gathering any additional information regarding the national classification methods adopted to assess the status of the individual Biological Quality Elements present in these waters. Such information would be of significant assistance to Malta to determine the most appropriate methods for such waters.

Thanking you for your kind cooperation.

Yours sincerely,

Manuel Sapiano
Water Director for Malta

AUBERGE DE CASTILLE, VALLETTA
TELEPHONE: 2229 2500 FAX: 2200 2511 EMAIL: mecw@gov.mt

Gerald Dörflinger

From: Gerald Dörflinger <gdorflinger@wdd.moa.gov.cy>
Sent: 06 August 2014 10:58
To: Manuel Sapiano (manuel.sapiano@gov.mt)
Subject: Information regarding the designation of small water bodies

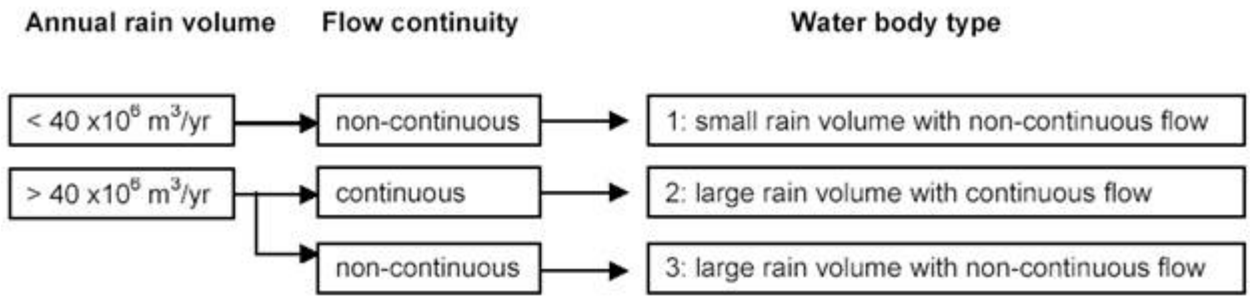
WDD file no.: 4.02.002.06.37, 4.2.2.6, 5.22.001

Dear Mr Sapiano,

With reference to your email dated 7/4/2014 on the above subject, please find below information related to the situation in Cyprus:

Transitional waters:
Cyprus did not define any transitional waters. There are no estuaries in Cyprus; only very few rivers reach their mouths and if they do, then only for a very limited time (days to few weeks). The tides are also very weak in Cyprus. For the above reasons there are no aquatic systems that would resemble transitional waters/estuaries.

Rivers:
In the initial WFD Article 5 water body network, for the 1st RBMP, Cyprus had defined a number of small ephemeral/episodic coastal catchments as water bodies. However, it became apparent that we can neither monitor/assess them (due to lack of flow and WFD BQEs) nor properly manage them for WFD purposes, as these dry rivers have no aquatic ecosystem in the sense of WFD BQEs. Therefore Cyprus will propose to remove them from its river water body network in the 2nd RBMP, using a threshold of 10km2 catchment area. Of course, these streams remain protected under national legislation. The original Cyprus river typology used for the 1st RBMP defines 3 types:



However, the above typology has shortcomings, and therefore Cyprus will propose a new river typology for the 2nd RBMP, with the flow regime as the main type descriptor (perennial-intermittent-ephemeral/episodic), so we can differentiate our streams according to the QEs we can use to assess their status. In particular, it is important to separate the dry-intermittent and ephemeral rivers where BQEs are not applicable. This is the only way I found to solve the issue of applicability of QEs in different rivers i.e. to justify why certain QEs are not applied in certain river types. Relevant is the work that was done in the MIRAGE project by e.g. Franc Gallart and Narcis Prat:

Prat, Narcís, Gallart, F., von Schiller, D, Polesello, S, et al. (2014) 'The mirage toolbox: an integrated assessment tool for temporary streams', River Research and Applications. DOI 10.1002/rra.2757

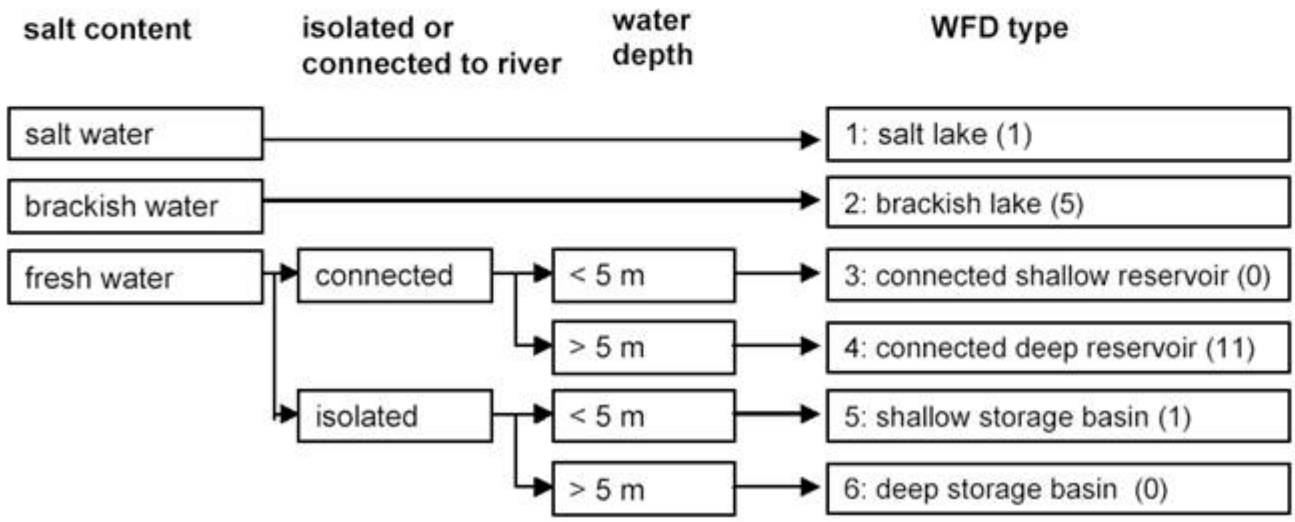
Cyprus will propose the following types for the 2nd RBMP:

- Perennial mountain streams (type P)
- Intermittent streams (type I)
- Harsh intermittent streams (type Ih)
- Ephemeral/episodic streams (type E)

In our perennial and intermittent rivers we monitor invertebrates and diatoms, macrophytes only in perennial rivers, our method for intermittent rivers does not work well enough to be used for classification. We did not monitor fish yet as there is very few.

The river sizes you mention in your email are indeed tiny. Several countries have used a length threshold of 1km when they delineated WFD streams. Still, if you have enough flow in these streams to support WFD BQEs, then you could assess and manage them. If they are purely ephemeral/episodic, it is probably an unnecessary burden to make them WFD rivers, as long as you protect them on the national level.

Lakes:
Cyprus had designated about all its natural lakes as WFD water bodies in the initial Article 5 work for the 1st RBMP. There are 6 lake water bodies and their area ranges from 0.04 - 10km2. Besides the natural lakes, Cyprus has designated 11 water reservoirs and 1 artificial WB (storage basin). The typology for standing waters of Cyprus defines 6 types. For natural lakes it differentiates two types, salt lakes and brackish lakes.



In Cyprus natural lakes, monitoring is done by the Department of Fisheries and Marine Research. They monitor Chlorophyll a (not in all lakes though) and physicochemistry. We are currently running a project to define references conditions for Cyprus' natural lakes, looking at all WFD BQEs, and based on the outcome we hope to be able to start monitoring the feasible BQEs.

In reservoirs the only BQE monitored is phytoplankton, and we also monitor physicochemical parameters.

Again, the sizes you indicate for Maltese standing waters are tiny and all smaller than the smalles size category mentioned in WFD Annex II. But as for rivers, it depends on the existence of BQEs in them whether you can assess them or not.

If you want to discuss these issues further, we will be happy to provide our input and exchange views and experiences. I believe the Med countries should have much closer cooperation in these basic questions of WFD implementation, in particular because the issues of dryland aquatic systems are not addressed in the WFD itself and often it is very difficult to make these issues and problems understandable to the Commission.

Best regards,
Gerald Dörflinger

****

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Gerald Dörflinger

From: Claudine Cardona <Claudine.Cardona@mepa.org.mt>
Sent: 28 August 2014 11:04
To: gdorflinger@wdd.moa.gov.cy
Subject: Malta and Cyprus - Inland surface waters

Follow Up Flag: Follow up
Flag Status: Flagged

Dear Mr. Dörflinger,

Many thanks for your very helpful email, the contents of which reflect a similar situation to ours.

I am not sure if you are aware of Malta's situation with the designation of small waters and the subsequent retraction which led to a European Court of Justice case way back in 2010. Malta had informed the Commission that it's small waters, all being of ecological significance, would be retained under the Protected Area Registry of the WFD and be managed under the Natura 2000 regime but could not be maintained as WFD water bodies. This argument was unacceptable to the Commission. Malta has since been trying to monitor and apply different methods to classify the status in these waters. However just as your email testifies, this has proven to be a very difficult task and we are currently testing methods to see what works and what doesn't.

Unfortunately the size threshold criterion as described by yourself has been presented to the Commission time and time over and has always been rebutted. The CION’s argument is that using size crietrion in countries where there are thousands of small streams is one matter, but in a country where small waters are the only waters is another matter altogether.

All of our waters have been heavily engineered time and time over and therefore if Malta decides to designate these waters, they would probably be as heaviliy modified waters. At this stage the type of designation is not of primary concern - rather the means to set tentative reference conditions for each of the BQEs is what is considered to be the most difficult. True, the benchmark conditions would be set according to the degree of disturbance at the site, but we first have to find adequate methods that could apply to each of the BQEs in ways which would make sense.

<u>Water courses</u>
We are in agreement with Cyprus that flow is a key parameter in the case of water courses and we are now trying to establish the flow regime in these waters. The typology being described by Cyprus as adapted from the MIRAGE project makes perfect sense and Malta will probably follow suit.
However it will be some time yet before one can actually establish a flow regime because we need years of data and we have only just started.

- Flow regime
The difficulty we have classifying our waters using the flow criterion (ie. whether they are permanent, intermittent or ephemeral) is also due to the fact that they are discontinuous at different parts of their reach. For instance how would one categorise a watercourse whose upper reach has continuous flow, whilst the middle and lower reaches dry out? Or a water course whose upper reaches have less water and even dry out whilst the lower reaches have water all year round due to connectivity with groundwater? Would a method to assess BQEs in the parts where there is running water be the same as the method applied to the ephemeral part of the stream? Does Cyprus also consider hyporheic flow?

- *BQEs*
Similar to Cyprus we have no fish in our water courses. The BQEs we have monitored to date are benthic invertebrates and walk over surveys for macrophytes and phytobenthos. For Macroinvertebrates we have applied the Extended Biotic Index. However this method is highly influenced by the presence/absence of sensitive indicator groups which are widespread in Alpine rivers or monutain rivers and tend to rarefy towards sea level. The index calculated here us therefore expected to be lower than the corresponding values from a continental river, regardless of the actual pollution level.

As for macrophytes no assessment method has been applied to date. We will be testing the Italian IBMR nethod (Bilogical Macrophytes Index for Rivers) in the upcoming monitoring programme. Physico-chemical elements are also monitored in these waters.

Lakes
We have 2 standing freshwater pools, one which is more akin to a natural water body, whilst the other has been greatly modified. They are both isolated and rather shallow. We monitored phytoplankton, physio-chemical parameters and macroinvertbrates. The same problem with the method for macroinvertebrates as described above for watercourses applies to these waters.

I am curious to know why Cyprus has not monitored macroinvertebrates in the natural lakes - is this because you have not applied any methods as yet? Also has Cyprus applied any method to assess the degree of eutrophication in these lakes?

Once again I would like to thank you for your kind assistance and discussion on this topic. It is immensely appreciated!

Kind regards,
Claudine

Claudine Cardona
Environment Protection Officer (Water)

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Gerald Dörflinger

From:	Claudine Cardona <Claudine.Cardona@mepa.org.mt>
Sent:	13 October 2014 16:18
To:	Gerald Dörflinger
Subject:	RE: Malta and Cyprus - Inland surface waters
Follow Up Flag:	Follow up
Flag Status:	Completed

Dear Gerald,

Many thanks for your very helpful feedback - it is a clear indication that Malta and Cyprus seem to both be on the same page with respect to these waters. I will definitely have a look at the MEDGIG technical milestone reports regarding the different BQEs. In the meantime we are awaiting the Commission's technical team to get back to us regarding our queries related to the designation of these small waters. Since Cyprus intends to retract the designation of some of the waters our experience may be of interest to you so I will keep you posted with any progress on the matter.

Kind regards,
Claudine

From: Gerald Dörflinger [mailto:gdorflinger@wdd.moa.gov.cy]
Sent: 06 October 2014 10:40
To: Claudine Cardona
Subject: RE: Malta and Cyprus - Inland surface waters

WDD file no.: 4.02.002.06.37, 4.2.2.6, 5.22.001

Dear Claudine,

I have finally found some time to put together my thoughts on your email below. I have written my comments into your text, marking them with *** and highlighted.

It is a pleasure to exchange views on these issues!

Best regards,
Gerald

****
Gerald Dörflinger
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From: Claudine Cardona [mailto:Claudine.Cardona@mepa.org.mt]
Sent: 09 September 2014 09:32
To: Gerald Dörflinger
Subject: RE: Malta and Cyprus - Inland surface waters

Dear Gerald,

Many thanks for your kind reply. I am no stranger to extremely busy times and understand completely. We can exchange emails on this matter at a later date when it is more convenient for you.

Kind regards,
Claudine

From: Gerald Dörflinger [mailto:gdorflinger@wdd.moa.gov.cy]
Sent: 09 September 2014 08:28
To: Claudine Cardona
Subject: RE: Malta and Cyprus - Inland surface waters

< span lang=EN-US style='color:#1F497D'>Dear Claudine,

This is just to let you know that I received your email well, but did not find the time to reply yet. I will also travel over the next week, so I hope to send my response until 22/9 approx.

I am sorry for the delay, but these are very busy times!

Best regards,
Gerald

****
Gerald Dörflinger
Hydrologist
Div. of Hydrometry

Water Development Dept.

Cyprus
Tel.: +357 22609354
Fax: +357 22609353
Email: gdorflinger@wdd.moa.gov.cy

From: Claudine Cardona [mailto:Claudine.Cardona@mepa.org.mt]
Sent: 28 August 2014 11:04
To: gdorflinger@wdd.moa.gov.cy
Subject: Malta and Cyprus - Inland surface waters

Dear Mr. Dörflinger,

Many thanks for your very helpful email, the contents of which reflect a similar sit uation to ours.

I am not sure if you are aware of Malta's situation with the designation of small waters and the subsequent retraction which led to a European Court of Justice case way back in 2010. Malta had informed the Commission that it's small waters, all being of ecological significance, would be retained under the Protected Area Registry of the WFD and be managed under the Natura 2000 regime but could not be maintained as WFD water bodies. This argument was unacceptable to the Commission. Malta has since been trying to monitor and apply different methods to classify the status in these waters. However just as your email testifies, this has proven to be a very difficult task and we are currently testing methods to see what works and what doesn't.

Unfortunately the size threshold criterion as described by yourself has been presented to the Commission time and time over and has always been rebutted. The CION's argument is that using size crietrion in countries where there are thousands of small streams is one matter, but in a country where small waters are the only waters is another matter altogether.

*** While I can to some extent understand the argument of COMM (i.e. every MS should protect its waters even if they are very small), I also believe that this leads to different treatment of MSs because countries with many and large WBs would not consider at all the small waters you have to deal with now. The important thing is to make COMM understand how difficult it is to apply the WFD in these waters. Inland water systems in Malta but also in Cyprus are extreme environments due to the dry climate, there is very little knowledge about these systems, assessment methods are rare, their functioning is more complex than the typical European perennial waters and the WFD (the Directive itself and its implementation) does not consider them sufficiently; there is only one temporary river type in the whole intercalibration process!

All of our waters have been heavily engineered time and time over and therefore if Malta decides to designate these waters, they would probably be as heaviliy modified waters. At this stage the type of designation is not of primary concern

*** I can understand your approach, we have also seen it like this for long time and perhaps still do. When you designate as natural WB, on one hand it is easier to find comparable waters and reference conditions, but you either have to comply with intercalibration results or proof why your waters do not fit any of the intercalibration types. On the other hand, when you designate as HMWB, things are "less binding", you can "estimate" the significant adverse effect on your uses (to my understanding a rather flexible exercise without much guidelines), and then set your m itigation measures and the GEP – again in a rather flexible way. Still, it will be interesting to see how strictly COMM will check how MSs are assessing and managing their HMWBs in the 2nd RBMPs.

- rather the means to set tentative reference conditions for each of the BQEs is what is considered to be the most difficult. True, the benchmark conditions would be set according to the degree of disturbance at the site, but we first have to find adequate methods that could apply to each of the BQEs in ways which would make sense.

*** I understand the difficulty involved, which is exacerbated by the fact that you have very few water bodies to work with and so there is little chance to detect a pressure and impact gradient. If this is the case, then do you know of comparable systems in other countries, so you could compare yours to them? Especially comparable systems in very good (reference) condition would be helpful so you can see how far your systems are from these (i.e. in the sense of an EQR scale). One option would be to use the intercalibra tion data sets (e.g. for small Mediterranean perennial rivers, and for temporary rivers) and add your data to it, so you can see where you stand.

Water courses

We are in agreement with Cyprus that flow is a key parameter in the case of water courses and we are now trying to establish the flow regime in these waters. The typology being described by Cyprus as adapted from the MIRAGE project makes perfect sense and Malta will probably follow suit.
However it will be some time yet before one can actually establish a flow regime because we need years of data and we have only just started.

*** It is true that most methods would require at least 20 years of data, but in my work for Cyprus' new river types , in some cases, I was able to assign MIRAGE TSR types based on few years of data only (4-5 years). Of course there is uncertainty when you assign regime types based on few years data, but the TSR method allows you to judge the probability of making assigning a wrong type: from the plotting position of a flow gauging station on the TSR chart you can see directly how close to the boundary between two types the data point is located – when you are close to a boundary you may not assign a type to that site, but when you are well within one type on the chart, there is very little risk the TSR would change so much with more data that it would change type; I would also say according to my experience that the results are rather robust.

- *Flow regime*

The difficulty we have classifying our waters using the flow criterion (ie. whether they are permanent, intermittent or ephemeral) is also due to the fact that they are discontinuous at different parts of their reach. For instance how would one categorise a watercourse whose upper reach has continuous flow, whilst the middle and lower reaches dry out?

*** Here you would need to classify each reach in its TSR type, so you would have a perennial water body in the upper reach, and the middle and lower reaches would be WBs with intermittent and/or ephemeral flow. The difficult thing here is to decide on the spatial resolution of your water body network, i.e. what would be your size limit for delineating a separate water body? I.e., if you have a perennial headwater stream of only a few hundred meters length, would you delineate this as a separate water body, or would you join it to the further downstream intermittent reach because it is too short? In my work, there were some cases of locally limited perennial reaches, caused by local springs, within otherwise intermittent rivers. I had one case where this perennial reach was about 4.5km long, and I k ept it as a separate water body (with adjacent intermittent WBs upstream and downstream of it), but other cases where the perennial reach was less than 2kms and of smaller hydro-ecological value I did not designate a separate water body in the end. In my view these are expert judgement decisions, please do not consider the lengths I mentioned above as "size limits". For every river reach a different combination of factors determines its significance, so in one case you may designate a very short water body due to difference in flow regime, while in another case you may not designate a longer reach of river; we also have to keep in mind that the length of the perennial/intermittent reach varies from year to year (and we do not have flow data on this variation, just judgements from riparian vegetation).

Or a water course whose upper reaches have less water and even dry out whilst the lower reaches have water all year round due to connectivity with groundwater? Would a method to assess BQEs in the parts where there is running water be the same as the method applied to the ephemeral part of the stream?

*** No, these methods would be different - at least when we consider the assessment methods we have available at the moment. According to the MIRAGE papers from Prat, Nicolaides, Gallart etc. and confirmed by our experience in Cyprus, we can apply the same methods for perennial rivers and for intermittent-pool rivers (the P and I-P TSR types from the MIRAGE project). We can even apply these very same methods in intermittent-dry rivers, but in the latter only in "normally wet&# 8221; years, not after years of major droughts, and with great care in interpreting the results, because we may not notice the impact of a shorter-than-normal flow period on the biota (we would perhaps think it is "normal" natural variation). As I understand it, we could reject doubtful results in these I-D rivers. In ephemeral rivers, according to my knowledge there are no methods that correspond to the WFD BQEs. Cyprus does not assess ephemeral rivers with BQEs, just by physico-chemistry (and priority substances, but for chemical status of course).

Does Cyprus also consider hyporheic flow?

***No, we do not explicitly consider hyporheic flow for WFD purposes (in the sense of a parameter or metric), but of course we appreciate its role for the functioning of our rivers.

- *BQEs*

Similar to Cyprus we have no fish in our water courses. The BQEs we have monitored to date are benthic invertebrates and walk over surveys for macrophytes and phytobenthos. For Macroinvertebrates we have applied the Extended Biotic Index. However this method is highly influenced by the presence/absence of sensitive indicator groups which are widespread in Alpine rivers or monutain rivers and tend to rarefy towards sea level. The index calculated here us therefore expected to be lower than the corresponding values from a continental river, regardless of the actual pollution level.

*** For a list of available indexes, you can look at the website of the WISER project (http://www.wiser.eu/results/method-database/) where most of the methods used in the EU for WFD assessments are included with quite good information in each method. For methods used in the Mediterranean intercalibration (probably more interesting for you), you can see the technical reports:

https://circabc.europa.eu/w/browse/a4c946c8-4c34-4ab0-ae76-8e0f274e7da9

The Mediterranean rivers reports are at (reports named "MED…."):

https://circabc.europa.eu/w/browse/2844e1cc-7776-48b1-b410-b4dcc8d10a27

In Cyprus we use the following indices for rivers:

- StarICMi for macroinvertebrates
- IPS for phytobenthos
- IBMR for macrophytes (perennial rivers only)

I have not heard of the Extended Biotic Index, but would suggest you try the indices used by other Mediterranean countries.

As for macrophytes no assessment method has been applied to date. We will be testing the Italian IBMR nethod (Bilogical Macrophytes Index for Rivers) in the upcoming monitoring programme. Physico-chemical elements are also monitored in these waters.

*** The most important thing is to check whether your index is responding to pressure variables; if it does not, don't use it. Of course these relationships are rarely clear and easy to see, and a grea t lot of statistics is sometimes used to make them visible, but you should be convinced that your index allows gauging the human impact on the water system you are looking at. For index selection and method development, we have always worked with consultants from abroad, as we do not have this expertise in the country. The procedure was usually to calculate several indices and compare to pressures, then select the one with best response to the pressures. Of course it is also crucial which indices to use for describing the pressures.

Lakes

We have 2 standing freshwater pools, one which is more akin to a n atural water body, whilst the other has been greatly modified. They are both isolated and rather shallow. We monitored phytoplankton, physio-chemical parameters and macroinvertbrates. The same problem with the method for macroinvertebrates as described above for watercourses applies to these waters.

I am curious to know why Cyprus has not monitored macroinvertebrates in the natural lakes - is this because you have not applied any methods as yet? Also has Cyprus applied any method to assess the degree of eutrophication in these lakes?

*** For the natural lakes we are very much at the beginning still, in a situation very similar to yours: few systems, different between each other, most of them impacted (no reference). We have not defined reference conditions yet, and because there are so few lakes, but still each one is a bit different from the other, it is very difficult to assess them. We have sampled for macroinvertebrates in the natural lakes last winter, but found macroinvertebrates only in two lakes out of 7; there are none in the lakes with saltier water. In the two where we found macroinvertebrates, diversity was very low, mostly chironomidae. As for eutrophication, nutrients are monitored but no EQS to assess for eutrophication are available yet.

Once again I would like to thank you for your kind assistance and discussion on this topic. It is immensely appreciated!

Kind regards,
Claudine

Claudine Cardona
Environment Protection Officer (Water)

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Appendix 8 Streams of the WFD stream network

AA	Catchment code	River name	Catchment area – total [km²]	Catchment area under Government control* [km²]	Catchment area under Government control* [%]	River type at river mouth	Distance to source [km]
1	1-1	Khapotami	112.3	112.3	100%	Ih	48.5
2	1-2	Dhiarizos	261.7	261.7	100%	I	52.4
3	1-3	Xeros Potamos	228.4	228.4	100%	E	48.6
4	1-4	Potamos tis Ezousas	224.8	224.8	100%	Ih	48.9
5	1-5	Limnarka	14.5	14.5	100%	E	11.5
6	1-5	Kochinas	13.3	13.3	100%	E	11.2
7	1-5	Agriokalami	11.7	11.7	100%	E	7.8
8	1-6	Mavrokolymbos	39.6	39.6	100%	Ih	16.4
9	1-6	Xeros	20.5	20.5	100%	Ih	12.3
10	1-8	Kalamouli (Avgas)	26.6	26.6	100%	Ih	11.2
11	1-8	Pevkos Potamos	16.3	16.3	100%	Ih	7.7
12	2-1	Argaki tou Ayiou Ioanni	18.7	18.7	100%	E	11.4
13	2-2	Khrysokhou Potamos	195.3	195.3	100%	Ih	36.2
14	2-3	Mirmikoph	21.6	21.6	100%	Ih	16.3
15	2-3	Argaki tis Limnis	11.8	11.8	100%	Ih	10.0
16	2-3	Potamos tis Magoundas	56.2	56.2	100%	Ih	19.5
17	2-3	Xeropotamos	10.3	10.3	100%	E	8.3
18	2-3	Yialias Potamos	20.1	20.1	100%	I	12.0
19	2-4	Xeros	10.5	10.5	100%	Ih	8.5
20	2-4	Livadhi	42.3	42.3	100%	Ih	16.9
21	2-5	Ayios Theodoros	15.6	15.6	100%	Ih	10.7
22	2-6	Katouris	28.5	28.5	100%	Ih	15.8

AA	Catchment code	River name	Catchment area – total [km²]	Catchment area under Government control* [km²]	Catchment area under Government control* [%]	River type at river mouth	Distance to source [km]
23	2-7	Potamos tou Pyrgou	55.3	53.8	97%	I	25.0
24	2-8	Potamos tou Limniti	74.4	66.2	89%	I	26.3
25	2-9	Potamos tou Kambou	50.4	42.9	85%	E	20.3
26	3-1	Xeros	80.1	70.6	88%	Ih	26.6
27	3-2	Setrakhos	81.9	72	88%	I	27.6
28	3-3	Karyiotis	93.3	88.8	95%	I	32.0
29	3-4	Atsas	53.3	47.2	89%	E	30.0
30	3-5	Potamos tis Elias	156.5	142.9	91%	Ih	37.7
31	3-6	Xeropotamos	19.7	11.5	58%	E**	14.8
32	3-6	Potami	30.8	27.7	90%	E**	18.3
33	3-6	Komitis	32.3	28.1	87%	E**	16.4
34	3-7	Serrakhis	693.4	492.2	71%	E	62.9
35	6-1	Pedhieos	1077.0	267.8	25%	No data	116.9
36	6-5	Yialias	878.2	410.3	47%	No data	97.5
37	7-2	Vathys	12.2	12.2	100%	Ih***	15.1
38	7-2	Liopetri	57.2	57.2	100%	E	13.8
39	8-2	Aradippou & Avdellero	97.6	97.6	100%	E	23.7
40	8-3	Kalo Chorio	27.9	27.9	100%	E***	13.5
41	8-3	[no name identified]	14.0	14	100%	E***	8.4
42	8-4	Tremithos	156.7	156.5	100%	E	40.9
43	8-5	Pouzis	53.4	53.4	100%	E	22.9
44	8-6	Xeropotamos	46.1	46.1	100%	Ih**	17.3
45	8-7	Pendaskhinos	167.5	167.5	100%	Ih	36.7

AA	Catchment code	River name	Catchment area – total [km^2]	Catchment area under Government control* [km^2]	Catchment area under Government control* [%]	River type at river mouth	Distance to source [km]
46	8-8	Potamos tou Ayiou Mina	58.8	58.8	100%	E	35.9
47	8-9	Vasilikos	150.5	150.5	100%	Ih	35.7
48	9-1	Pendakomo	15.5	15.5	100%	E	8.7
49	9-1	Argaki tou Pyrgou	67.7	67.7	100%	E	15.8
50	9-2	Potamos tis Yermasogeias	176.7	176.7	100%	Ih	39.1
51	9-3	Vathias	20.1	20.1	100%	E	12.3
52	9-4	Vathias	14.9	14.9	100%	E	10.9
53	9-4	Garyllis	85.2	85.2	100%	E	28.7
54	9-5	Ypsonas	12.7	12.7	100%	E**	11.0
55	9-6	Kouris	339.6	339.6	100%	I	47.0
56	9-7	Krommya	12.5	12.5	100%	E**	8.2
57	9-7	Symvoulas	28.0	28	100%	E	14.5
58	9-8	Potamos tou Paramaliou	46.6	46.6	100%	Ih	21.3
59	9-8	Evdhimou	59.0	59	100%	Ih	13.0
60	9-9	Villourka	31.5	31.5	100%	E	14.3
		TOTAL	6529.2	4974.3	76%		-

*) Refers to the area under Government control, i.e. it excludes the areas of the Republic of Cyprus in which the Government of the Republic of Cyprus does not exercise effective control.

**) River disappears inland due to percolation and evaporation before reaching the sea, usually spreading out over flat (agricultural) land; there is no river mouth to the sea.

***) River discharges into a natural lake.

Appendix 9 Rivers added to the stream network

AA	Catchment code	Catchment name	Stream name	DA [km^2]	Length [km]
1	8-3	Kalo Chorio Larnakas	Kalo Chorio stream	27.9	7.9
2	8-3	Kalo Chorio Larnakas		14.0	3.9
3	9-1	Argaki tou Pyrgou	Pentakomo stream	15.5	8.2
4	9-3	Ag. Athanasios	Vathias	20.1	8.2
5	9-4	Garyllis	Vathias	14.9	5.7
6	9-7	Episkopi	Krommya	12.5	7.0
			TOTAL	104.9	40.9

Appendix 10 Streams removed from the WFD stream network (does not include removed tributaries)

AA	Catchment code	WB_cd_2005	Stream/reach name	DA [km^2]	Length [km]
1	1-2	CY_1-2-9_R3	Argakin tou Yiakoupi	9.7	5.2
2	1-5	CY_1-5-8_R3	Appis	7.1	8.1
3	1-7	CY_1-7-1_R1	Katsiris	3.2	6.3
4	1-7	CY_1-7-6_R1	Aspros	8.4	6.6
5	1-9	CY_1-9-1_R1	Mirillis	2.6	4.6
6	1-9	CY_1-9-3_R1	Argaki ton Theorakion	1.7	2.9
7	1-9	CY_1-9-5_R1	Argakin tou Dhimmatou	3.9	3.4
8	1-9	CY_1-9-7_R1	Argakin tou Kouvernouri	2.4	4.4
9	1-9	CY_1-9-8_R1	Argaki tou Mouzouri	1.8	2.3
10	1-9	CY_1-9-91_R1	Argaki tis Klokkarkas	0.3	0.8
11	1-9	CY_1-9-92_R1	Argaki tou Apopoulou	1.6	1.5
12	2-1	CY_2-1-11_R1	Argaki ton Kolymboudhion	0.4	1.5
13	2-1	CY_2-1-12_R1	Argaki tous Exosyrondes	1.0	2
14	2-1	CY_2-1-2_R1	Argaki tou Pyrgou & Argaki tou Kephalovrysou	3.1	5.7
15	2-1	CY_2-1-3_R1	Argaki tou Vatou	0.8	1.9
16	2-1	CY_2-1-6_R1	Petratis	9.1	7.7
17	2-5	CY_2-5-2_R1	Makroyeni & Akoni Potamos (Kokkina)	6.4	5
18	2-6	CY_2-6-4_R1	Potamoudhiou Potamos	6.4	3
19	7-2	CY_7-2-4_R3-HM	Unnamed (no channel developed)	2.1	0
20	7-2	CY_7-2-51_R3	Unnamed	1.9	0.7
21	7-2	CY_7-2-52_R3	unnamed	1.3	1.8
22	7-2	CY_7-2-53_R3	Unnamed	2.3	1.5
23	7-2	CY_7-2-54_R3	Unnamed (Mana tou nerou area)	1.8	3.2
24	7-2	CY_7-2-71_R3	Unnamed	1.9	2.5
25	7-2	CY_7-2-72_R3	Unnamed	1.8	2.2
			TOTAL	83	84.8

Appendix 11 Water Bodies proposed for designation as HMWB, that need to be evaluated for final designation or not in the course of the preparation of the 2nd RBMP

Catchment code	Catchment name	Water Body code 2nd RBMP	Water Body code 1st RBMP	Stream name
1-1	Chapotami	CY_1-1-d_RIh_HM	CY_1-1-4_R3	Khapotami
1-5	Geroskipou	CY_1-5-d_RE_HM (d/s part)	CY_1-5-51_R3	Kochinas
6-1	Pediaios	CY_6-1-j_RE_HM	NONE	Klemos
6-1	Pediaios	CY_6-1-k_RE_HM	NONE	Katevas
6-1	Pediaios	CY_6-1-n_RE_HM	NONE	Dhrakondias
8-2	Aradippou	CY_8-2-b_RE_HM	CY_8-2-1_R1	Aradippou
9-3	Ag. Athanasios	CY_9-3-b_RE_HM	NONE	Vathias (WS 9-3 Ag. Athanasios, Mesa Geitonia)
9-4	Garyllis	CY_9-4-a_RE_HM	CY_9-4-42_R3-HM	Vathias (WS 9-4)

Appendix 12 Water Bodies of the 1st RBMP that are removed from the WFD stream network by this study

AA	Water body code 1st RBMP	Catchment code	Catchment name	Tributary/stream	Stream length [km]
1	CY_1-2-51_R3	1-2	Diarizos	tributary	3.9
2	CY_1-2-52_R3	1-2	Diarizos	tributary	4.2
3	CY_1-2-61_R3	1-2	Diarizos	tributary	3.7
4	CY_1-2-62_R3	1-2	Diarizos	tributary	2.5
5	CY_1-2-8_R3	1-2	Diarizos	tributary	4.4
6	CY_1-2-9_R3	1-2	Diarizos	whole stream	5.2
7	CY_1-3-8_R3	1-3	Xeros	tributary	2.0
8	CY_1-3-9_R3	1-3	Xeros	tributary	3.1
9	CY_1-4-42_R3	1-4	Ezousa	tributary	4.4
10	CY_1-4-43_R3	1-4	Ezousa	tributary	7.9
11	CY_1-4-9_R3	1-4	Ezousa	tributary	2.1
12	CY_1-4-9_R3-HM	1-4	Ezousa	tributary	1.7
13	CY_1-5-8_R3	1-5	Geroskipou	whole stream	8.1
14	CY_1-7-1_R1	1-7	Pegeia	whole stream	6.3
15	CY_1-7-6_R1	1-7	Pegeia	whole stream	6.6
16	CY_1-9-1_R1	1-9	West Akamas	whole stream	4.6
17	CY_1-9-3_R1	1-9	West Akamas	whole stream	2.9
18	CY_1-9-5_R1	1-9	West Akamas	whole stream	3.4
19	CY_1-9-7_R1	1-9	West Akamas	whole stream	4.4
20	CY_1-9-8_R1	1-9	West Akamas	whole stream	2.3
21	CY_1-9-91_R1	1-9	West Akamas	whole stream	0.8
22	CY_1-9-92_R1	1-9	West Akamas	whole stream	1.5
23	CY_2-1-11_R1	2-1	Agios Ioannis	whole stream	1.5
24	CY_2-1-12_R1	2-1	Agios Ioannis	whole stream	2.0
25	CY_2-1-2_R1	2-1	Agios Ioannis	whole stream	5.7
26	CY_2-1-3_R1	2-1	Agios Ioannis	whole stream	1.9
27	CY_2-1-6_R1	2-1	Agios Ioannis	whole stream	7.7
28	CY_2-2-6_R3	2-2	Chrysochou	tributary	1.8
29	CY_2-5-2_R1	2-5	Kochina	whole stream	5.0
30	CY_2-6-4_R1	2-6	Katouris	whole stream	3.0
31	CY_2-9-3_R1	2-9	Kampos	tributary	3.7
32	CY_3-1-31_R3	3-1	Xeros	tributary	1.4
33	CY_3-1-32_R3	3-1	Xeros	tributary	2.3
34	CY_3-1-33_R3	3-1	Xeros	tributary	5.6
35	CY_3-2-1-2_R3	3-2	Makounta	tributary	2.7
36	CY_3-2-2_R3	3-2	Makounta	tributary	3.5
37	CY_3-4-2_R1	3-4	Atsas	tributary	0.2
38	CY_3-5-13_R3	3-5	Elias	tributary	8.0
39	CY_3-5-41_R3	3-5	Elias	tributary	0.8
40	CY_3-5-42_R3	3-5	Elias	tributary	0.5

AA	Water body code 1st RBMP	Catchment code	Catchment name	Tributary/stream	Stream length [km]
41	CY_3-7-12_R3	3-7	Serrachis	tributary	0.7
42	CY_3-7-1_R3	3-7	Serrachis	tributary	3.4
43	CY_3-7-31_R3	3-7	Serrachis	tributary	4.8
44	CY_6-1-22_R3	6-1	Pediaios	tributary	1.5
45	CY_6-5-31_R3	6-5	Gialias	tributary	3.3
46	CY_6-5-32_R3	6-5	Gialias	tributary	6.8
47	CY_7-1-4_R1	7-1	Ammochostos	tributary	10.3
48	CY_7-1-61_R3	7-1	Ammochostos	tributary	3.0
49	CY_7-1-62_R3	7-1	Ammochostos	tributary	2.6
50	CY_7-1-6_R3-HM	7-1	Ammochostos	tributary	0.3
51	CY_7-2-4_R3-HM	7-2	Liopetri	whole stream	0.3
52	CY_7-2-51_R3	7-2	Liopetri	whole stream	0.7
53	CY_7-2-52_R3	7-2	Liopetri	whole stream	1.8
54	CY_7-2-53_R3	7-2	Liopetri	whole stream	1.5
55	CY_7-2-54_R3	7-2	Liopetri	whole stream	3.2
56	CY_7-2-71_R3	7-2	Liopetri	whole stream	2.5
57	CY_7-2-72_R3	7-2	Liopetri	whole stream	2.2
58	CY_8-7-12_R3	8-7	Pentaschoinos	tributary	3.8
59	CY_8-7-13_R3	8-7	Pentaschoinos	tributary	0.9
60	CY_8-7-2_R3	8-7	Pentaschoinos	tributary	2.8
61	CY_8-9-5_R3	8-9	Vasilikos	tributary	1.4
62	CY_9-2-12_R2	9-2	Germasogeia	tributary	1.3
63	CY_9-4-3_R3	9-4	Garillis	tributary	4.0
64	CY_9-6-22_R3	9-6	Kouris	tributary	6.7
65	CY_9-6-2_R3	9-6	Kouris	tributary	7.0
66	CY_9-6-34_R3	9-6	Kouris	tributary	0.6
67	CY_9-6-71_R3	9-6	Kouris	tributary	8.1

Appendix 13 List of river water bodies of the 2nd RBMP, including the corresponding water bodies of the 1st RBMP. The table does not include impounded rivers (i.e. water reservoirs).

AA	Water Body code	River type	River name	River name (Greek)	Occupied**	HMWB	Length [km]	Catchment code	Catchment name	Water Body code 1st RBMP
1	CY_1-1-a_RP	P	Khapotami	Χαποτάμι	NO	NO	5.9	1-1	Chapotami	CY_1-1-1_R3
2	CY_1-1-b_RI	I	Khapotami	Χαποτάμι	NO	NO	17.2	1-1	Chapotami	CY_1-1-1_R3, CY_1-1-4_R3
3	CY_1-1-c_RIh	Ih	Khapotami	Χαποτάμι	NO	NO	19.3	1-1	Chapotami	CY_1-1-4_R3
4	CY_1-1-d_RIh_HM	Ih	Khapotami	Χαποτάμι	NO	YES*	4.8	1-1	Chapotami	CY_1-1-4_R3
5	CY_1-1-e_RI	I	Malleta	Μαλέτης	NO	NO	9.6	1-1	Chapotami	CY_1-1-1_R3
6	CY_1-2-a_RP	P	Dhiarizos	Διαρίζος	NO	NO	38.6	1-2	Diarizos	CY_1-2-1_R2
7	CY_1-2-b_RP	P	Dhiarizos	Διαρίζος	NO	NO	20.1	1-2	Diarizos	CY_1-2-1_R2
8	CY_1-2-d_RI_HM	I	Dhiarizos	Διαρίζος	NO	YES	31.3	1-2	Diarizos	CY_1-2-4_R3-HM
9	CY_1-2-e_RI	I	Tholo Potamos	Θολός	NO	NO	7.5	1-2	Diarizos	CY_1-2-1_R2
10	CY_1-2-f_RIh	Ih	Yerovasinos Potamos	Γεροβάσινος	NO	NO	11.2	1-2	Diarizos	CY_1-2-53_R3
11	CY_1-3-a_RP	P	Argaki tis Roudhias	Ρουδιάς	NO	NO	42.0	1-3	Xeros	CY_1-3-1_R2, CY_1-3-5_R3
12	CY_1-3-b_RI	I	Xeros Potamos	Ξερός Ποταμός	NO	NO	6.4	1-3	Xeros	CY_1-3-5_R3
13	CY_1-3-c_RIh	Ih	Xeros Potamos	Ξερός Ποταμός	NO	NO	11.7	1-3	Xeros	CY_1-3-5_R3
14	CY_1-3-e_RE_HM	E	Xeros Potamos	Ξερός Ποταμός	NO	YES	3.9	1-3	Xeros	CY_1-3-9_R3-HM
15	CY_1-3-f_RI	I	Argaki Lazaridhaes	Λαζαρήδες	NO	NO	6.5	1-3	Xeros	CY_1-3-1_R2
16	CY_1-3-g_RIh	Ih	Argaki ton Lefkarkon	Λευκαρκών	NO	NO	8.2	1-3	Xeros	CY_1-3-5_R3
17	CY_1-4-a_RP	P	Ayia & Klimadhiou	Αγυιά & Κλιμαδιού	NO	NO	13.6	1-4	Ezousas	CY_1-4-1_R3
18	CY_1-4-b_RI	I	Argaki tis Ayias	Αγυιά	NO	NO	7.5	1-4	Ezousas	CY_1-4-1_R3
19	CY_1-4-d_RI_HM	I	Potamos tis Ezousas	Έζουσα	NO	YES	7.4	1-4	Ezousas	CY_1-4-3_R3-HM
20	CY_1-4-e_RIh_HM	Ih	Potamos tis Ezousas	Έζουσα	NO	YES	4.8	1-4	Ezousas	CY_1-4-3_R3-HM
21	CY_1-4-f_RP_HM	P	Potamos tis Ezousas	Έζουσα	NO	YES	5.2	1-4	Ezousas	CY_1-4-3_R3-HM
22	CY_1-4-g_RI_HM	I	Potamos tis Ezousas	Έζουσα	NO	YES	5.9	1-4	Ezousas	CY_1-4-3_R3-HM

AA	Water Body code	River type	River name	River name (Greek)	Occupied**	HMWB	Length [km]	Catchment code	Catchment name	Water Body code 1st RBMP
23	CY_1-4-h_RIh_HM	Ih	Potamos tis Ezousas	Έζουσα	NO	YES	8.1	1-4	Ezousas	CY_1-4-3_R3-HM
24	CY_1-4-i_RI	I	Argaki tou Paleomylou	Παλιόμυλου	NO	NO	5.6	1-4	Ezousas	CY_1-4-41_R3
25	CY_1-4-j_RIh	Ih	Argakin tou Ayiou Nepiou	Άγιος Νεπίος	NO	NO	7.1	1-4	Ezousas	CY_1-4-51_R3
26	CY_1-4-k_RIh	Ih	Varkas	Βαρκάς	NO	NO	14.1	1-4	Ezousas	CY_1-4-6_R3
27	CY_1-4-L_RIh	Ih	Milarkou Potamos	Μυλάρι	NO	NO	12.9	1-4	Ezousas	CY_1-4-52_R3
28	CY_1-4-m_RIh	Ih	Kochatis	Κοσιάτης	NO	NO	13.2	1-4	Ezousas	CY_1-4-3_R3
29	CY_1-5-a_RE	E	Limnarka	Λιμνάρκα	NO	NO	12.0	1-5	Geroskipou	CY_1-5-2_R3
30	CY_1-5-b_RE_HM	E	Limnarka	Λιμνάρκα	NO	YES	1.5	1-5	Geroskipou	CY_1-5-2_R3-HM
31	CY_1-5-c_RE	E	Kochinas	Κοχχινάς	NO	NO	7.7	1-5	Geroskipou	CY_1-5-5_R3
32	CY_1-5-d_RE_HM	E	Kochinas	Κοχχινάς	NO	YES	3.0	1-5	Geroskipou	CY_1-5-5_R3-HM, CY_1-5-51_R3
33	CY_1-5-e_RE	E	Agriokalami	Αρκοκαλάμι	NO	NO	7.2	1-5	Geroskipou	CY_1-5-7_R3
34	CY_1-6-a_RIh	Ih	Mavrokolymbos	Μαυροκόλυμπος	NO	NO	11.9	1-6	Mavrokolympos	CY_1-6-2_R1
35	CY_1-6-c_RIh_HM	Ih	Mavrokolymbos	Μαυροκόλυμπος	NO	YES	2.7	1-6	Mavrokolympos	CY_1-6-1_R2-HM
36	CY_1-6-d_RIh	Ih	Xeros	Ξερός	NO	NO	17.1	1-6	Mavrokolympos	CY_1-6-3_R1
37	CY_1-8-a_RIh	Ih	Kalamouli (Avgas)	Καλαμούλι (Αυγάς)	NO	NO	18.3	1-8	Avgas	CY_1-8-1_R1
38	CY_1-8-b_RIh	Ih	Pevkos Potamos	Πεύκος	NO	NO	15.3	1-8	Avgas	CY_1-8-4_R1
39	CY_2-1-a_RE	E	Argaki tou Ayiou Ioanni	Αγίου Ιωάννη	NO	NO	12.8	2-1	East Akamas	CY_2-1-7_R1
40	CY_2-2-a_RIh	Ih	Neraidhes & Potamos Ammadhkiou	Νεράδες & Αμμακού	NO	NO	21.0	2-2	Chrysochou	CY_2-2-1_R3
41	CY_2-2-b_RI	I	Garillis Potamos	Γαρύλλης	NO	NO	6.2	2-2	Chrysochou	CY_2-2-1_R3
42	CY_2-2-c_RI	I	Potamos tou Stavrou tis Psokas	Σταυρός της Ψώκας	NO	NO	36.6	2-2	Chrysochou	CY_2-2-4_R3
43	CY_2-2-d_RI	I	Potamos tou Stavrou tis Psokas	Σταυρός της Ψώκας	NO	NO	5.8	2-2	Chrysochou	CY_2-2-4_R3

AA	Water Body code	River type	River name	River name (Greek)	Occupied**	HMWB	Length [km]	Catchment code	Catchment name	Water Body code 1st RBMP
44	CY_2-2-f_RI_HM	I	Potamos tou Stavrou tis Psokas	Σταυρός της Ψώκας	NO	YES	2.7	2-2	Chrysochou	CY_2-2-6_R3-HM
45	CY_2-2-g_RI_HM	I	Khrysokhou Potamos	Χρυσοχού	NO	YES	2.8	2-2	Chrysochou	CY_2-2-6_R3-HM
46	CY_2-2-h_RIh_HM	Ih	Khrysokhou Potamos	Χρυσοχού	NO	YES	6.8	2-2	Chrysochou	CY_2-2-6_R3-HM
47	CY_2-3-a_RIh	Ih	Mirmikoph	Μιρμικόφου	NO	NO	15.0	2-3	Magounta	CY_2-3-1_R3
48	CY_2-3-b_RIh	Ih	Argaki tis Limnis	Αργάκι της Λίμνης	NO	NO	8.5	2-3	Magounta	CY_2-3-2_R3
49	CY_2-3-c_RI	I	Potamos tis Magoundas	Μακούντα	NO	NO	24.7	2-3	Magounta	CY_2-3-3_R3
50	CY_2-3-d_RIh_HM	Ih	Potamos tis Magoundas	Μακούντα	NO	YES	4.0	2-3	Magounta	CY_2-3-5_R3-HM
51	CY_2-3-e_RE	E	Xeropotamos	Ξεροπόταμος	NO	NO	7.6	2-3	Magounta	CY_2-3-7_R3
52	CY_2-3-f_RP	P	Yialias Potamos	Γιαλιά	NO	NO	10.9	2-3	Magounta	CY_2-3-8_R3
53	CY_2-3-g_RI	I	Yialias Potamos	Γιαλιά	NO	NO	1.1	2-3	Magounta	CY_2-3-8_R3
54	CY_2-4-a_RIh	Ih	Xeros	Ξερός	NO	NO	4.2	2-4	Xeros	CY_2-4-2_R3
55	CY_2-4-b_RIh_HM	Ih	Xeros	Ξερός	NO	YES	2.9	2-4	Xeros	CY_2-4-2_R3-HM
56	CY_2-4-c_RP	P	Maroti & Diali	Μαρώτης & Διάλι	NO	NO	6.1	2-4	Xeros	CY_2-4-4_R3
57	CY_2-4-d_RI	I	Livadhi	Λειβάδι	NO	NO	8.7	2-4	Xeros	CY_2-4-4_R3
58	CY_2-4-e_RIh_HM	Ih	Livadhi	Λειβάδι	NO	YES	4.0	2-4	Xeros	CY_2-4-3_R3-HM
59	CY_2-5-a_RIh	Ih	Ayios Theodoros	Άγιος Θεόδωρος	NO	NO	9.6	2-5	Kochina	CY_2-5-3_R1
60	CY_2-6-a_RIh	Ih	Katouris	Κατούρης	NO	NO	9.9	2-6	Katouris	CY_2-6-1_R1
61	CY_2-6-b_RIh_HM	Ih	Katouris	Κατούρης	NO	YES	5.3	2-6	Katouris	CY_2-6-3_R1-HM
62	CY_2-7-a_RI	I	Potamos tou Pyrgou	Πύργος	NO	NO	30.2	2-7	Pyrgos	CY_2-7-1_R1
63	CY_2-8-a_RP	P	Potamos tou Limniti	Λιμνίτης	NO	NO	33.2	2-8	Limnitis	CY_2-8-1_R3
64	CY_2-8-b_RI	I	Potamos tou Limniti	Λιμνίτης	YES	NO	4.2	2-8	Limnitis	CY_2-8-1_R3
65	CY_2-9-a_RI	I	Potamos tou Kambou	Κάμπος	NO	NO	2.4	2-9	Kampos	NONE

AA	Water Body code	River type	River name	River name (Greek)	Occupied**	HMWB	Length [km]	Catchment code	Catchment name	Water Body code 1st RBMP
66	CY_2-9-b_RP	P	Potamos tou Kambou	Κάμπος	NO	NO	7.3	2-9	Kampos	CY_2-9-1_R1
67	CY_2-9-c_RI	I	Potamos tou Kambou	Κάμπος	NO	NO	2.6	2-9	Kampos	CY_2-9-1_R1
68	CY_2-9-d_RIh_HM	Ih	Potamos tou Kambou	Κάμπος	NO	YES	3.0	2-9	Kampos	CY_2-9-4_R1-HM
69	CY_2-9-e_RE_HM	E	Potamos tou Kambou	Κάμπος	YES	YES	3.7	2-9	Kampos	CY_2-9-4_R1-HM
70	CY_3-1-a_RP	P	Xeros	Ξερός	NO	NO	9.9	3-1	Xeros	CY_3-1-1_R3
71	CY_3-1-b_RI	I	Xeros	Ξερός	NO	NO	2.5	3-1	Xeros	CY_3-1-1_R3
72	CY_3-1-c_RI_HM	I	Xeros	Ξερός	NO	YES	9.5	3-1	Xeros	CY_3-1-2_R3-HM
73	CY_3-1-d_RIh_HM	Ih	Xeros	Ξερός	YES	YES	4.0	3-1	Xeros	CY_3-1-2_R3-HM
74	CY_3-2-a_RP	P	Marathasa	Μαραθάσα	NO	NO	15.8	3-2	Marathasa	CY_3-2-1_R2
75	CY_3-2-b_RP_HM	P	Marathasa	Μαραθάσα	NO	YES	12.1	3-2	Marathasa	CY_3-2-2_R3-HM, CY_3-2-4_R3-HM
76	CY_3-2-c_RI_HM	I	Setrakhos	Σέτραχος	YES	YES	6.0	3-2	Marathasa	CY_3-2-4_R3-HM
77	CY_3-2-d_RI	I	Rkondas	Ρκόντας	NO	NO	5.8	3-2	Marathasa	NONE
78	CY_3-2-e_RE	E	Vrountokremni Argakin	Βρουντόκρεμοι	NO	NO	12.8	3-2	Marathasa	CY_3-2-3_R3
79	CY_3-3-a_RP	P	Ayios Nikolaos	Άγιος Νικόλαος	NO	NO	14.8	3-3	Kargotis	CY_3-3-1_R2
80	CY_3-3-b_RP	P	Karyiotis	Καργώτης	NO	NO	13.4	3-3	Kargotis	CY_3-3-1_R2
81	CY_3-3-c_RI	I	Karyiotis	Καργώτης	NO	NO	11.4	3-3	Kargotis	CY_3-3-4_R3
82	CY_3-3-d_RP	P	Argaki tou Karvouna	Αργακί του Καρβουνά	NO	NO	12.6	3-3	Kargotis	CY_3-3-1_R2
83	CY_3-3-e_RI	I	Alykhnos	Άλυχνος	NO	NO	6.1	3-3	Kargotis	CY_3-3-1_R2
84	CY_3-4-a_RI	I	Atsas	Ατσάς	NO	NO	15.3	3-4	Atsas	CY_3-4-1_R1
85	CY_3-4-b_RIh	Ih	Atsas	Ατσάς	NO	NO	2.1	3-4	Atsas	CY_3-4-1_R1
86	CY_3-4-c_RIh_HM	Ih	Atsas	Ατσάς	NO	YES	6.0	3-4	Atsas	CY_3-4-3_R1-HM
87	CY_3-4-d_RE_HM	E	Atsas	Ατσάς	YES	YES	6.5	3-4	Atsas	CY_3-4-3_R1-HM
88	CY_3-5-a_RI	I	Lagoudhera	Λαγουδερά	NO	NO	11.8	3-5	Elia	CY_3-5-11_R3
89	CY_3-5-c_RI_HM	I	Lagoudhera	Λαγουδερά	NO	YES	12.6	3-5	Elia	CY_3-5-1_R3-HM
90	CY_3-5-d_RIh_HM	Ih	Potamos tis Elias	Ελιά	NO	YES	13.3	3-5	Elia	CY_3-5-1_R3-HM

AA	Water Body code	River type	River name	River name (Greek)	Occupied**	HMWB	Length [km]	Catchment code	Catchment name	Water Body code 1st RBMP
91	CY_3-5-e_RI	I	Kannavia	Καννάβια	NO	NO	15.4	3-5	Elia	CY_3-5-2_R3
92	CY_3-5-f_RI	I	Asinou	Ασίνου	NO	NO	15.3	3-5	Elia	CY_3-5-3_R3
93	CY_3-5-g_RE	E	Galouropniktis Potamos	Γαδουροπνίκτης	NO	NO	13.1	3-5	Elia	NONE
94	CY_3-6-a_RE	E	Xeropotamos	Ξεροπόταμος	NO	NO	12.8	3-6	Xeros	CY_3-6-1_R3
95	CY_3-6-b_RE	E	Potami	Ποτάμι	NO	NO	18.1	3-6	Xeros	CY_3-6-2_R3
96	CY_3-6-c_RE	E	Komitis	Κομίτης	NO	NO	19.6	3-6	Xeros	CY_3-6-3_R3
97	CY_3-7-a_RI	I	Peristerona	Περιστερώνα	NO	NO	53.2	3-7	Serrachis	CY_3-7-11_R3
98	CY_3-7-b_RIh	Ih	Peristerona	Περιστερώνα	NO	NO	6.7	3-7	Serrachis	CY_3-7-11_R3
99	CY_3-7-c_RE	E	Peristerona	Περιστερώνα	NO	NO	8.0	3-7	Serrachis	CY_3-7-11_R3
100	CY_3-7-d_RI	I	Maroullenas	Μαρούλλενα	NO	NO	12.6	3-7	Serrachis	CY_3-7-34_R3
101	CY_3-7-e_RI	I	Kambi	Καμπί	NO	NO	7.5	3-7	Serrachis	CY_3-7-33_R3
102	CY_3-7-f_RI_HM	I	Maroullenas	Μαρούλλενα	NO	YES	13.4	3-7	Serrachis	CY_3-7-3_R3-HM
103	CY_3-7-g_RI	I	Pharmakas	Φαρμακάς	NO	NO	13.2	3-7	Serrachis	CY_3-7-32_R3
104	CY_3-7-h_RI_HM	I	Pharmakas	Φαρμακάς	NO	YES	3.0	3-7	Serrachis	CY_3-7-3_R3-HM
105	CY_3-7-j_RIh_HM	Ih	Potamos tou Akakiou	Ακάκι	NO	YES	4.5	3-7	Serrachis	CY_3-7-41_R3-HM
106	CY_3-7-k_RE_HM	E	Potamos tou Akakiou	Ακάκι	NO	YES	16.9	3-7	Serrachis	CY_3-7-41_R3-HM, CY_3-7-42_R3-HM
107	CY_3-7-L_RE	E	Korivas	Κορύβας	NO	NO	10.3	3-7	Serrachis	NONE
108	CY_3-7-m_RE	E	Likythia	Λυκίδια	NO	NO	32.2	3-7	Serrachis	CY_3-7-2_R3
109	CY_3-7-n_RIh	Ih	Koutis & Aloupos	Κούτης & Αλουπός	NO	NO	22.4	3-7	Serrachis	CY_3-7-51_R3
110	CY_3-7-o_RE	E	Merika	Μερίκα	NO	NO	24.8	3-7	Serrachis	CY_3-7-51_R3, CY_3-7-52_R3
111	CY_3-7-p_RE	E	Kokkinitrimithia	Κοκκινοτριμιθία	NO	NO	13.6	3-7	Serrachis	CY_3-7-52_R3
112	CY_3-7-q_RE_HM	E	Serrakhis	Σερράχης	YES	YES	19.3	3-7	Serrachis	CY_3-7-42_R3-HM
113	CY_3-7-r_RE	E	Ovgos	Οβγός	NO	NO	27.7	3-7	Serrachis	CY_3-7-6_R3
114	CY_3-7-s_R	NoDat	Ovgos	Οβγός	YES	NO	37.5	3-7	Serrachis	CY_3-7-6_R3
115	CY_6-1-a_RIh	Ih	Pedhieos & Ayios Onouphrios	Πεδιαίος & Αγίου Ονουφρίου	NO	NO	30.0	6-1	Pediaios	CY_6-1-1_R3

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116	CY_6-1-c_RIh_HM	Ih	Pedhieos	Πεδιαίος	NO	YES	1.0	6-1	Pediaios	CY_6-1-1_R3
117	CY_6-1-d_RE_HM	E	Pedhieos	Πεδιαίος	NO	YES	20.3	6-1	Pediaios	CY_6-1-21_R3
118	CY_6-1-e_RE_HM	E	Pedhieos	Πεδιαίος	NO	YES	9.1	6-1	Pediaios	CY_6-1-2_R3-HM
119	CY_6-1-f_R	NoDat	Pedhieos	Πεδιαίος	YES	NO	82.0	6-1	Pediaios	CY_6-1-4_R3
120	CY_6-1-g_RE	E	Kouphos	Κουφός	NO	NO	6.9	6-1	Pediaios	NONE
121	CY_6-1-h_RE	E	Argaki	Αργάκι	NO	NO	9.9	6-1	Pediaios	NONE
122	CY_6-1-i_RE	E	Klemos	Κλήμος	NO	NO	4.5	6-1	Pediaios	NONE
123	CY_6-1-j_RE_HM	E	Klemos	Κλήμος	NO	YES*	8.6	6-1	Pediaios	NONE
124	CY_6-1-k_RE_HM	E	Katevas	Κατεβάς	NO	YES*	10.3	6-1	Pediaios	NONE
125	CY_6-1-L_RE	E	Kaloyeros	Καλόγυρος	NO	NO	15.6	6-1	Pediaios	CY_6-1-51_R3
126	CY_6-1-m_RE_HM	E	Vathys	Βαθύς	NO	YES	13.1	6-1	Pediaios	CY_6-1-5_R3-HM
127	CY_6-1-n_RE_HM	E	Dhrakondias	Δρακοντιά	NO	YES*	6.9	6-1	Pediaios	NONE
128	CY_6-1-o_RE	E	Vyzakotos	Βυζακωτός	NO	NO	4.2	6-1	Pediaios	NONE
129	CY_6-1-p_RE	E	Almyros	Αλμυρός	NO	NO	24.3	6-1	Pediaios	CY_6-1-52_R3
130	CY_6-5-a_RIh	Ih	Yialias	Γιαλιάς	NO	NO	13.0	6-5	Gialias	CY_6-5-12_R3
131	CY_6-5-b_RI	I	Yialias	Γιαλιάς	NO	NO	12.8	6-5	Gialias	CY_6-5-12_R3, CY_6-5-2_R3
132	CY_6-5-c_RE	E	Yialias	Γιαλιάς	NO	NO	18.6	6-5	Gialias	CY_6-5-2_R3
133	CY_6-5-d_R	NoDat	Yialias	Γιαλιάς	YES	NO	40.7	6-5	Gialias	NONE
134	CY_6-5-e_RIh	Ih	Koutsos	Κουτσός	NO	NO	8.6	6-5	Gialias	CY_6-5-11_R3
135	CY_6-5-f_RIh_HM	Ih	Koutsos	Κουτσός	NO	YES	6.2	6-5	Gialias	CY_6-5-1_R3-HM
136	CY_6-5-g_RE	E	Argaki ton Villourkon	Βιλλούρια	NO	NO	9.5	6-5	Gialias	NONE
137	CY_6-5-h_RE	E	Alykos	Άλυκος	NO	NO	31.2	6-5	Gialias	CY_6-5-2_R3
138	CY_6-5-i_RE	E	Almyros	Αλμυρός	NO	NO	20.9	6-5	Gialias	CY_6-5-2_R3
139	CY_7-2-a_RIh	Ih	Vathys	Βαθύς	NO	NO	6.6	7-2	Liopetri	CY_7-2-6_R3
140	CY_7-2-b_RE	E	Liopetri	Λιοπέτρι	NO	NO	5.7	7-2	Liopetri	CY_7-2-3_R3
141	CY_7-2-c_RE_HM	E	Liopetri	Λιοπέτρι	NO	YES	2.5	7-2	Liopetri	CY_7-2-3_R3-HM
142	CY_8-1-a_RE	E	Avdellero	Αβδελλερό	NO	NO	6.7	8-1	Voroklini	CY_8-1-2_R1

AA	Water Body code	River type	River name	River name (Greek)	Occupied**	HMWB	Length [km]	Catchment code	Catchment name	Water Body code 1st RBMP
143	CY_8-1-b_RE_HM	E	Avdellero	Αβδελλερό	NO	YES	6.8	8-1	Voroklini	CY_8-1-2_R1-HM
144	CY_8-2-a_RE	E	Aradippou	Αραδίππου	NO	NO	32.6	8-2	Aradippou	CY_8-2-1_R1
145	CY_8-2-b_RE_HM	E	Aradippou	Αραδίππου	NO	YES*	5.2	8-2	Aradippou	CY_8-2-1_R1
146	CY_8-3-a_RE	E	Kalo Chorio	Καλό Χωριό	NO	NO	7.4	8-3	Larnaka salt lakes	NONE
147	CY_8-3-b_RE	E			NO	NO	3.7	8-3	Larnaka salt lakes	NONE
148	CY_8-4-a_RE	E	Ammos & Kalamoulia	Άμμος & Καλαμούλια	NO	NO	19.4	8-4	Treminthos	CY_8-4-11_R3, CY_8-4-12_R3
149	CY_8-4-b_RE	E	Xylias	Ξυλιάς	NO	NO	8.6	8-4	Treminthos	CY_8-4-13_R3
150	CY_8-4-c_RE_HM	E	Tremithos	Τρέμινθος	NO	YES	24.3	8-4	Treminthos	CY_8-4-1_R3-HM
151	CY_8-4-d_RE_HM	E	Tremithos	Τρέμινθος	NO	YES	6.8	8-4	Treminthos	CY_8-4-5_R3-HM
152	CY_8-4-e_RE	E	Ayia Marina	Αγία Μαρίνα	NO	NO	2.2	8-4	Treminthos	NONE
153	CY_8-4-f_RE	E	Mosfiloti	Μοσφιλωτή	NO	NO	11.6	8-4	Treminthos	CY_8-4-2_R3
154	CY_8-4-g_RE	E	Ayios Ioannis	Άγιος Ιωάννης	NO	NO	15.2	8-4	Treminthos	CY_8-4-4_R3
155	CY_8-5-a_RIh	Ih	Pouzis	Πούζης	NO	NO	16.1	8-5	Pouzis	CY_8-5-1_R1
156	CY_8-5-b_RE	E	Pouzis	Πούζης	NO	NO	8.2	8-5	Pouzis	CY_8-5-1_R1
157	CY_8-5-c_RE	E	Xeropouzos	Ξερόπουζος	NO	NO	13.3	8-5	Pouzis	CY_8-5-1_R1
158	CY_8-6-a_RIh	Ih	Xeropotamos	Ξεροπόταμος	NO	NO	18.9	8-6	Xeros	CY_8-6-1_R3
159	CY_8-7-a_RI	I	Syrkatis	Συριάτης	NO	NO	20.0	8-7	Pentaschoinos	CY_8-7-11_R3
160	CY_8-7-c_RI_HM	I	Syrkatis	Συριάτης	NO	YES	6.7	8-7	Pentaschoinos	CY_8-7-2_R3_HM
161	CY_8-7-d_RIh	Ih	Argaki tou Mylou	Μύλου	NO	NO	16.9	8-7	Pentaschoinos	CY_8-7-3_R3
162	CY_8-7-f_RI_HM	I	Pendaskhinos	Πεντάσχοινος	NO	YES	7.3	8-7	Pentaschoinos	CY_8-7-4_R3-HM
163	CY_8-7-g_RIh_HM	Ih	Pendaskhinos	Πεντάσχοινος	NO	YES	9.5	8-7	Pentaschoinos	CY_8-7-4_R3-HM
164	CY_8-7-h_RE	E			NO	NO	10.5	8-7	Pentaschoinos	CY_8-7-5_R3
165	CY_8-8-a_RI	I	Potamos tou Ayiou Mina	Αγίου Μηνά	NO	NO	16.8	8-8	Maroni	CY_8-8-1_R3

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166	CY_8-8-b_RIh	Ih	Potamos tou Ayiou Mina	Αγίου Μηνά	NO	NO	2.9	8-8	Maroni	CY_8-8-1_R3, CY_8-8-2_R3-HM
167	CY_8-8-c_RIh_HM	Ih	Potamos tou Ayiou Mina	Αγίου Μηνά	NO	YES	8.1	8-8	Maroni	CY_8-8-2_R3-HM
168	CY_8-8-d_RE_HM	E	Potamos tou Ayiou Mina	Αγίου Μηνά	NO	YES	7.4	8-8	Maroni	CY_8-8-2_R3-HM
169	CY_8-9-a_RI	I	Vasilikos	Βασιλικός	NO	NO	5.5	8-9	Vasilikos	CY_8-9-1_R3
170	CY_8-9-b_RI_HM	I	Vasilikos	Βασιλικός	NO	YES	2.1	8-9	Vasilikos	CY_8-9-1_R3-HM
171	CY_8-9-c_RI	I	Vasilikos	Βασιλικός	NO	NO	33.0	8-9	Vasilikos	CY_8-9-2_R3
172	CY_8-9-e_RI_HM	I	Vasilikos	Βασιλικός	NO	YES	9.0	8-9	Vasilikos	CY_8-9-5_R3-HM
173	CY_8-9-f_RIh_HM	Ih	Vasilikos	Βασιλικός	NO	YES	4.5	8-9	Vasilikos	CY_8-9-5_R3-HM
174	CY_8-9-g_RIh	Ih	Exovounia	Εξωβούνια	NO	NO	9.7	8-9	Vasilikos	CY_8-9-2_R3
175	CY_8-9-h_RIh	Ih	Argaki tis Asgatas	Ασγάτα	NO	NO	13.1	8-9	Vasilikos	NONE
176	CY_9-1-a_RE	E	Pendakomo	Πεντάκωμο	NO	NO	7.9	9-1	Argaki tou Pyrgou	NONE
177	CY_9-1-b_RIh	Ih	Argaki tou Pyrgou	Πύργος	NO	NO	11.0	9-1	Argaki tou Pyrgou	CY_9-1-4_R3
178	CY_9-1-c_RE	E	Argaki tou Pyrgou	Πύργος	NO	NO	3.7	9-1	Argaki tou Pyrgou	CY_9-1-4_R3
179	CY_9-1-d_RE	E	Argaki tou Pyrgou	Πύργος	NO	NO	2.9	9-1	Argaki tou Pyrgou	CY_9-1-4_R3
180	CY_9-1-e_RE	E	Argaki tis Monis	Μονή	NO	NO	10.1	9-1	Argaki tou Pyrgou	NONE
181	CY_9-2-a_RI	I	Karydhaki	Καρυδάκι	NO	NO	17.6	9-2	Germasogeia	CY_9-2-2_R2
182	CY_9-2-b_RP	P	Ayios Pavlos	Άγιος Παύλος	NO	NO	6.5	9-2	Germasogeia	NONE
183	CY_9-2-c_RI	I	Potamos tis Yermasogeias	Γερμασόγεια	NO	NO	5.2	9-2	Germasogeia	CY_9-2-11_R2
184	CY_9-2-d_RI_HM	I	Potamos tis Yermasogeias	Γερμασόγεια	NO	YES	2.6	9-2	Germasogeia	CY_9-2-1_R2-HM
185	CY_9-2-e_RI	I	Potamos tis Yermasogeias	Γερμασόγεια	NO	NO	5.7	9-2	Germasogeia	CY_9-2-2_R2, CY_9-2-31_R3

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186	CY_9-2-f_RI	I	Potamos tis Yermasogeias	Γερμασόγεια	NO	NO	9.1	9-2	Germasogeia	CY_9-2-31_R3
187	CY_9-2-h_RIh_HM	Ih	Potamos tis Yermasogeias	Γερμασόγεια	NO	YES	6.4	9-2	Germasogeia	CY_9-2-5_R3-HM
188	CY_9-2-i_RIh	Ih	Argaki Pissokamina	Πισσοκάμινα	NO	NO	7.6	9-2	Germasogeia	CY_9-2-32_R3
189	CY_9-2-j_RI	I	Yialiadhes	Γυαλλιάδες	NO	NO	9.1	9-2	Germasogeia	CY_9-2-4_R2
190	CY_9-2-k_RI	I	Yialiadhes	Γυαλλιάδες	NO	NO	4.3	9-2	Germasogeia	CY_9-2-4_R2
191	CY_9-2-L_RI_HM	I	Yialiadhes	Γυαλλιάδες	NO	YES	2.1	9-2	Germasogeia	CY_9-2-4_R3-HM
192	CY_9-3-a_RE	E	Vathias (Ag. Athanasios)	Βαθιά	NO	NO	6.9	9-3	Ag. Athanasios	NONE
193	CY_9-3-b_RE_HM	E	Vathias (Ag. Athanasios)	Βαθιά	NO	YES*	5.0	9-3	Ag. Athanasios	NONE
194	CY_9-4-a_RE_HM	E	Vathias	Βαθιά	NO	YES*	5.6	9-4	Garyllis	CY_9-4-42_R3-HM
195	CY_9-4-b_RI	I	Garyllis	Γαρύλλης	NO	NO	24.2	9-4	Garyllis	CY_9-4-1_R3
196	CY_9-4-c_RI	I	Garyllis	Γαρύλλης	NO	NO	3.9	9-4	Garyllis	CY_9-4-1_R3
197	CY_9-4-e_RIh_HM	Ih	Garyllis	Γαρύλλης	NO	YES	3.8	9-4	Garyllis	CY_9-4-41_R3-HM
198	CY_9-4-f_RE_HM	E	Garyllis	Γαρύλλης	NO	YES	4.4	9-4	Garyllis	CY_9-4-42_R3-HM
199	CY_9-4-g_RIh	Ih	Phasoula	Φασούλλα	NO	NO	7.8	9-4	Garyllis	NONE
200	CY_9-5-a_RE	E	Ypsonas	Ύψωνας	NO	NO	13.0	9-5	Akrotiri	CY_9-5-1_R3
201	CY_9-6-a_RP	P	Ayios Ioannis	Άγιος Ιωάννης	NO	NO	5.3	9-6	Kouris	CY_9-6-52_R2
202	CY_9-6-b_RP	P	Ambelikos-Agros	Αμπέλικος-Αγρός	NO	NO	17.6	9-6	Kouris	CY_9-6-5_R2, CY_9-6-51_R2, CY_9-6-52_R2
203	CY_9-6-c_RP	P			NO	NO	0.3	9-6	Kouris	CY_9-6-53_R2
204	CY_9-6-d_RP_HM	P			NO	YES	1.4	9-6	Kouris	CY_9-6-53_R2-HM
205	CY_9-6-e_RP	P	Ambelikos-Xylourikos	Αμπελικός-Ξυλούρικος	NO	NO	11.4	9-6	Kouris	CY_9-6-5_R2, CY_9-6-72_R3
206	CY_9-6-f_RI	I	Potamos tou Limnati	Λιμνάτης	NO	NO	7.0	9-6	Kouris	CY_9-6-72_R3
207	CY_9-6-g_RI	I	Pelendri	Πελένδρι	NO	NO	6.2	9-6	Kouris	NONE

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208	CY_9-6-h_RI	I	Ayios Mamas	Άγιος Μάμας	NO	NO	5.9	9-6	Kouris	NONE
209	CY_9-6-i_RP	P	Loumata	Λούματα	NO	NO	3.1	9-6	Kouris	CY_9-6-33_R3
210	CY_9-6-k_RP_HM	P	Loumata	Λούματα	NO	YES	2.9	9-6	Kouris	CY_9-6-33_R3-HM
211	CY_9-6-L_RP	P	Kouris	Κούρης	NO	NO	19.5	9-6	Kouris	CY_9-6-31_R3
212	CY_9-6-m_RP_HM	P	Kouris	Κούρης	NO	YES	13.1	9-6	Kouris	CY_9-6-4_R3-HM
213	CY_9-6-n_RP	P	Mesapotamos	Μέσα Ποταμός	NO	NO	6.5	9-6	Kouris	CY_9-6-35_R3
214	CY_9-6-o_RP	P	Moniatis	Μονιάτης	NO	NO	5.9	9-6	Kouris	CY_9-6-36_R3
215	CY_9-6-p_RP	P	Kryos	Κρυός	NO	NO	8.0	9-6	Kouris	CY_9-6-1_R2
216	CY_9-6-q_RP_HM	P	Kryos	Κρυός	NO	YES	6.0	9-6	Kouris	CY_9-6-1_R2-HM, CY_9-6-1_R3-HM
217	CY_9-6-r_RI_HM	I	Kryos	Κρυός	NO	YES	15.0	9-6	Kouris	CY_9-6-1_R3-HM
218	CY_9-6-t_RI_HM	I	Kouris	Κούρης	NO	YES	11.4	9-6	Kouris	CY_9-6-9_R3-HM
219	CY_9-6-u_RE	E	Batsounis	Πατσούνι	NO	NO	5.9	9-6	Kouris	CY_9-6-81_R3
220	CY_9-6-v_RE	E	Tapakhna	Ταπάχνα	NO	NO	5.5	9-6	Kouris	CY_9-6-82_R3
221	CY_9-6-w_RE_HM	E	Tapakhna	Ταπάχνα	NO	YES	1.6	9-6	Kouris	CY_9-6-8_R3-HM
222	CY_9-7-a_RE	E	Krommya	Κρομμύα	NO	NO	9.8	9-7	Episkopi	NONE
223	CY_9-7-b_RE	E	Symvoulas	Σύμβουλος	NO	NO	7.8	9-7	Episkopi	CY_9-7-1_R1
224	CY_9-7-c_RE_HM	E	Symvoulas	Σύμβουλος	NO	YES	5.0	9-7	Episkopi	CY_9-7-2_R1-HM
225	CY_9-8-a_RIh	Ih	Potamos tou Paramaliou	Παραμάλι	NO	NO	28.0	9-8	Avdimou	CY_9-8-1_R3
226	CY_9-8-b_RI	I	Evdhimou (Mandalas)	Αυδήμου (Μάνταλας)	NO	NO	11.3	9-8	Avdimou	CY_9-8-4_R3
227	CY_9-8-c_RIh	Ih	Evdhimou	Αυδήμου	NO	NO	4.2	9-8	Avdimou	CY_9-8-4_R3
228	CY_9-8-d_RE	E	Pantijo	Παντίκια	NO	NO	6.3	9-8	Avdimou	NONE
229	CY_9-8-e_RE	E	Argaki Paleomylos	Παλιόμυλος	NO	NO	5.3	9-8	Avdimou	NONE
230	CY_9-9-a_RE	E	Villourka	Βιλλούρκα	NO	NO	11.7	9-9	Pissouri	CY_9-9-3_R1

*) WBs proposed for identification as HMWB or not, in the course of the preparation of the 2nd RBMP

**) The water bodies characterized as “occupied” (i.e. “YES” in column “Occupied”) are located entirely in those areas of the Republic of Cyprus in which the Government of the Republic of Cyprus does not exercise effective control. According to the provisions of Article 1 of Protocol No 10 on Cyprus, attached to the Treaty of Accession to the EU, the application of the acquis is suspended in those areas of the Republic of Cyprus in which the Government of the Republic of Cyprus does not exercise effective control. Water bodies that cross the Green Line are not characterized as “occupied” in this table.

Appendix 14 List of river water bodies of the 1st RBMP and the corresponding water bodies of the 2nd RBMP

AA	Water Body code 1st RBMP	Water Body code	Stream/reach name
1	CY_1-1-1_R3	CY_1-1-a_RP	Khapotami
		CY_1-1-b_RI	Khapotami
		CY_1-1-e_RI	Malleta
2	CY_1-1-4_R3	CY_1-1-b_RI	Khapotami
		CY_1-1-c_RIh	Khapotami
		CY_1-1-d_RIh_HM	Khapotami
3	CY_1-2-1_R2	CY_1-2-a_RP	Dhiarizos
		CY_1-2-b_RP	Dhiarizos
		CY_1-2-e_RI	Tholo Potamos
4	CY_1-2-4_R3-HM	CY_1-2-d_RI_HM	Dhiarizos
5	CY_1-2-51_R3	NONE	
6	CY_1-2-52_R3	NONE	
7	CY_1-2-53_R3	CY_1-2-f_RIh	Yerovasinos Potamos
8	CY_1-2-61_R3	NONE	
9	CY_1-2-62_R3	NONE	
10	CY_1-2-8_R3	NONE	
11	CY_1-2-9_R3	NONE	
12	CY_1-3-1_R2	CY_1-3-a_RP	Argaki tis Roudhias
		CY_1-3-f_RI	Argaki Lazaridhaes
13	CY_1-3-5_R3	CY_1-3-a_RP	Argaki tis Roudhias
		CY_1-3-b_RI	Xeros Potamos
		CY_1-3-c_RIh	Xeros Potamos
		CY_1-3-g_RIh	Argaki ton Lefkarkon
14	CY_1-3-8_R3	NONE	
15	CY_1-3-9_R3	NONE	
16	CY_1-3-9_R3-HM	CY_1-3-e_RE_HM	Xeros Potamos
17	CY_1-4-1_R3	CY_1-4-a_RP	Ayia & Klimadhiou
		CY_1-4-b_RI	Argaki tis Ayias
18	CY_1-4-3_R3	CY_1-4-m_RIh	Kotchatis
19	CY_1-4-3_R3-HM	CY_1-4-d_RI_HM	Potamos tis Ezousas
		CY_1-4-e_RIh_HM	Potamos tis Ezousas
		CY_1-4-f_RP_HM	Potamos tis Ezousas
		CY_1-4-g_RI_HM	Potamos tis Ezousas
		CY_1-4-h_RIh_HM	Potamos tis Ezousas
20	CY_1-4-41_R3	CY_1-4-i_RI	Argaki tou Paleomylou
21	CY_1-4-42_R3	NONE	
22	CY_1-4-43_R3	NONE	
23	CY_1-4-51_R3	CY_1-4-j_RIh	Argakin tou Ayiou Nepiou
24	CY_1-4-52_R3	CY_1-4-L_RIh	Milarkou Potamos
25	CY_1-4-6_R3	CY_1-4-k_RIh	Varkas
26	CY_1-4-9_R3	NONE	
27	CY_1-4-9_R3-HM	NONE	

AA	Water Body code 1st RBMP	Water Body code	Stream/reach name
28	CY_1-5-2_R3	CY_1-5-a_RE	Limnarka
29	CY_1-5-2_R3-HM	CY_1-5-b_RE_HM	Limnarka
30	CY_1-5-5_R3	CY_1-5-c_RE	Kochinas
31	CY_1-5-5_R3-HM	CY_1-5-d_RE_HM	Kochinas
32	CY_1-5-51_R3	CY_1-5-d_RE_HM	Kochinas
33	CY_1-5-7_R3	CY_1-5-e_RE	Agriokalami
34	CY_1-5-8_R3	NONE	
35	CY_1-6-1_R2-HM	CY_1-6-c_RIh_HM	Mavrokolymbos
36	CY_1-6-2_R1	CY_1-6-a_RIh	Mavrokolymbos
37	CY_1-6-3_R1	CY_1-6-d_RIh	Xeros
38	CY_1-7-1_R1	NONE	
39	CY_1-7-6_R1	NONE	
40	CY_1-8-1_R1	CY_1-8-a_RIh	Kalamouli (Avgas)
41	CY_1-8-4_R1	CY_1-8-b_RIh	Pevkos Potamos
42	CY_1-9-1_R1	NONE	
43	CY_1-9-3_R1	NONE	
44	CY_1-9-5_R1	NONE	
45	CY_1-9-7_R1	NONE	
46	CY_1-9-8_R1	NONE	
47	CY_1-9-91_R1	NONE	
48	CY_1-9-92_R1	NONE	
49	CY_2-1-11_R1	NONE	
50	CY_2-1-12_R1	NONE	
51	CY_2-1-2_R1	NONE	
52	CY_2-1-3_R1	NONE	
53	CY_2-1-6_R1	NONE	
54	CY_2-1-7_R1	CY_2-1-a_RE	Argaki tou Ayiou Ioanni
55	CY_2-2-1_R3	CY_2-2-a_RIh	Neraidhes & Potamos Ammadhkiou
		CY_2-2-b_RI	Garillis Potamos
56	CY_2-2-4_R3	CY_2-2-c_RI	Potamos tou Stavrou tis Psokas
		CY_2-2-d_RI	Potamos tou Stavrou tis Psokas
57	CY_2-2-6_R3	NONE	
58	CY_2-2-6_R3-HM	CY_2-2-f_RI_HM	Potamos tou Stavrou tis Psokas
		CY_2-2-g_RI_HM	Khrysokhou Potamos
		CY_2-2-h_RIh_HM	Khrysokhou Potamos
59	CY_2-3-1_R3	CY_2-3-a_RIh	Mirmikoph
60	CY_2-3-2_R3	CY_2-3-b_RIh	Argaki tis Limnis
61	CY_2-3-3_R3	CY_2-3-c_RI	Potamos tis Magoundas
62	CY_2-3-5_R3-HM	CY_2-3-d_RIh_HM	Potamos tis Magoundas
63	CY_2-3-7_R3	CY_2-3-e_RE	Xeropotamos
64	CY_2-3-8_R3	CY_2-3-f_RP	Yialias Potamos
		CY_2-3-g_RI	Yialias Potamos
65	CY_2-4-2_R3	CY_2-4-a_RIh	Xeros
66	CY_2-4-2_R3-HM	CY_2-4-b_RIh_HM	Xeros
67	CY_2-4-3_R3-HM	CY_2-4-e_RIh_HM	Livadhi

AA	Water Body code 1st RBMP	Water Body code	Stream/reach name
68	CY_2-4-4_R3	CY_2-4-c_RP	Maroti & Diali
		CY_2-4-d_RI	Livadhi
69	CY_2-5-2_R1	NONE	
70	CY_2-5-3_R1	CY_2-5-a_RIh	Ayios Theodoros
71	CY_2-6-1_R1	CY_2-6-a_RIh	Katouris
71	CY_2-6-3_R1-HM	CY_2-6-b_RIh_HM	Katouris
73	CY_2-6-4_R1	NONE	
74	CY_2-7-1_R1	CY_2-7-a_RI	Potamos tou Pyrgou
75	CY_2-8-1_R3	CY_2-8-a_RP	Potamos tou Limniti
		CY_2-8-b_RI	Potamos tou Limniti
76	CY_2-9-1_R1	CY_2-9-b_RP	Potamos tou Kambou
		CY_2-9-c_RI	Potamos tou Kambou
77	CY_2-9-3_R1	NONE	
78	CY_2-9-4_R1-HM	CY_2-9-d_RIh_HM	Potamos tou Kambou
		CY_2-9-e_RE_HM	Potamos tou Kambou
79	CY_3-1-1_R3	CY_3-1-a_RP	Xeros
		CY_3-1-b_RI	Xeros
80	CY_3-1-2_R3-HM	CY_3-1-c_RI_HM	Xeros
		CY_3-1-d_RIh_HM	Xeros
81	CY_3-1-31_R3	NONE	
82	CY_3-1-32_R3	NONE	
83	CY_3-1-33_R3	NONE	
84	CY_3-2-1_R2	CY_3-2-a_RP	Marathasa
85	CY_3-2-1-2_R3	NONE	
86	CY_3-2-2_R3	NONE	
87	CY_3-2-2_R3-HM	CY_3-2-b_RP_HM	Marathasa
88	CY_3-2-3_R3	CY_3-2-e_RE	Vrountokremni Argakin
89	CY_3-2-4_R3-HM	CY_3-2-b_RP_HM	Marathasa
		CY_3-2-c_RI_HM	Setrakhos
90	CY_3-3-1_R2	CY_3-3-a_RP	Ayios Nikolaos
		CY_3-3-b_RP	Karyiotis
		CY_3-3-d_RP	Argaki tou Karvouna
		CY_3-3-e_RI	Alykhnos
91	CY_3-3-4_R3	CY_3-3-c_RI	Karyiotis
92	CY_3-4-1_R1	CY_3-4-a_RI	Atsas
		CY_3-4-b_RIh	Atsas
93	CY_3-4-2_R1	NONE	
94	CY_3-4-3_R1-HM	CY_3-4-c_RIh_HM	Atsas
		CY_3-4-d_RE_HM	Atsas
95	CY_3-5-1_R3-HM	CY_3-5-c_RI_HM	Lagoudhera
		CY_3-5-d_RIh_HM	Potamos tis Elias
96	CY_3-5-11_R3	CY_3-5-a_RI	Lagoudhera
97	CY_3-5-13_R3	NONE	
98	CY_3-5-2_R3	CY_3-5-e_RI	Kannavia
99	CY_3-5-3_R3	CY_3-5-f_RI	Asinou

AA	Water Body code 1st RBMP	Water Body code	Stream/reach name
100	CY_3-5-41_R3	NONE	
101	CY_3-5-42_R3	NONE	
102	CY_3-6-1_R3	CY_3-6-a_RE	Xeropotamos
103	CY_3-6-2_R3	CY_3-6-b_RE	Potami
104	CY_3-6-3_R3	CY_3-6-c_RE	Komitis
105	CY_3-7-1_R3	NONE	
106	CY_3-7-11_R3	CY_3-7-a_RI	Peristerona
		CY_3-7-b_RIh	Peristerona
		CY_3-7-c_RE	Peristerona
107	CY_3-7-12_R3	NONE	
108	CY_3-7-2_R3	CY_3-7-m_RE	Likythia
109	CY_3-7-3_R3-HM	CY_3-7-f_RI_HM	Maroullenas
		CY_3-7-h_RI_HM	Pharmakas
110	CY_3-7-31_R3	NONE	
111	CY_3-7-32_R3	CY_3-7-g_RI	Pharmakas
112	CY_3-7-33_R3	CY_3-7-e_RI	Kambi
113	CY_3-7-34_R3	CY_3-7-d_RI	Maroullenas
114	CY_3-7-41_R3-HM	CY_3-7-j_RIh_HM	Potamos tou Akakiou
		CY_3-7-k_RE_HM	Potamos tou Akakiou
115	CY_3-7-42_R3-HM	CY_3-7-k_RE_HM	Potamos tou Akakiou
		CY_3-7-q_RE_HM	Serrakhis
116	CY_3-7-51_R3	CY_3-7-n_RIh	Koutis & Aloupos
		CY_3-7-o_RE	Merika
117	CY_3-7-52_R3	CY_3-7-o_RE	Merika
		CY_3-7-p_RE	Kokkinitrimithia
118	CY_3-7-6_R3	CY_3-7-r_RE	Ovgos
		CY_3-7-s_R	Ovgos
119	CY_6-1-1_R3	CY_6-1-a_RIh	Pedhieos & Ayios Onouphrios
		CY_6-1-c_RIh_HM	Pedhieos
120	CY_6-1-2_R3-HM	CY_6-1-e_RE_HM	Pedhieos
121	CY_6-1-21_R3	CY_6-1-d_RE_HM	Pedhieos
122	CY_6-1-22_R3	NONE	
123	CY_6-1-4_R3	CY_6-1-f_R	Pedhieos
124	CY_6-1-5_R3-HM	CY_6-1-m_RE_HM	Vathys
125	CY_6-1-51_R3	CY_6-1-L_RE	Kaloyeros
126	CY_6-1-52_R3	CY_6-1-p_RE	Almyros
127	CY_6-5-1_R3-HM	CY_6-5-f_RIh_HM	Koutsos
128	CY_6-5-11_R3	CY_6-5-e_RIh	Koutsos
129	CY_6-5-12_R3	CY_6-5-a_RIh	Yialias
		CY_6-5-b_RI	Yialias
130	CY_6-5-2_R3	CY_6-5-b_RI	Yialias
		CY_6-5-c_RE	Yialias
		CY_6-5-h_RE	Alykos
		CY_6-5-i_RE	Almyros
131	CY_6-5-31_R3	NONE	

AA	Water Body code 1st RBMP	Water Body code	Stream/reach name
132	CY_6-5-32_R3	NONE	
133	CY_7-1-4_R1	NONE	
134	CY_7-1-6_R3-HM	NONE	
135	CY_7-1-61_R3	NONE	
136	CY_7-1-62_R3	NONE	
137	CY_7-2-3_R3	CY_7-2-b_RE	Liopetri
138	CY_7-2-3_R3-HM	CY_7-2-c_RE_HM	Liopetri
139	CY_7-2-4_R3-HM	NONE	
140	CY_7-2-51_R3	NONE	
141	CY_7-2-52_R3	NONE	
142	CY_7-2-53_R3	NONE	
143	CY_7-2-54_R3	NONE	
144	CY_7-2-6_R3	CY_7-2-a_RIh	Vathys
145	CY_7-2-71_R3	NONE	
146	CY_7-2-72_R3	NONE	
147	CY_8-1-2_R1	CY_8-1-a_RE	Avdellero
148	CY_8-1-2_R1-HM	CY_8-1-b_RE_HM	Avdellero
149	CY_8-2-1_R1	CY_8-2-a_RE	Aradippou
		CY_8-2-b_RE_HM	Aradippou
150	CY_8-4-1_R3-HM	CY_8-4-c_RE_HM	Tremithos
151	CY_8-4-11_R3	CY_8-4-a_RE	Ammos & Kalamoulia
152	CY_8-4-12_R3	CY_8-4-a_RE	Ammos & Kalamoulia
153	CY_8-4-13_R3	CY_8-4-b_RE	Xylias
154	CY_8-4-2_R3	CY_8-4-f_RE	Mosfiloti
155	CY_8-4-4_R3	CY_8-4-g_RE	Ayios Ioannis
156	CY_8-4-5_R3-HM	CY_8-4-d_RE_HM	Tremithos
157	CY_8-5-1_R1	CY_8-5-a_RIh	Pouzis
		CY_8-5-b_RE	Pouzis
		CY_8-5-c_RE	Xeropouzos
158	CY_8-6-1_R3	CY_8-6-a_RIh	Xeropotamos
159	CY_8-7-11_R3	CY_8-7-a_RI	Syrkatis
160	CY_8-7-12_R3	NONE	
161	CY_8-7-13_R3	NONE	
162	CY_8-7-2_R3	NONE	
163	CY_8-7-2_R3_HM	CY_8-7-c_RI_HM	Syrkatis
164	CY_8-7-3_R3	CY_8-7-d_RIh	Argaki tou Mylou
165	CY_8-7-4_R3-HM	CY_8-7-f_RI_HM	Pendaskhinos
		CY_8-7-g_RIh_HM	Pendaskhinos
166	CY_8-7-5_R3	CY_8-7-h_RE	
167	CY_8-8-1_R3	CY_8-8-a_RI	Potamos tou Ayiou Mina
		CY_8-8-b_RIh	Potamos tou Ayiou Mina
168	CY_8-8-2_R3-HM	CY_8-8-b_RIh	Potamos tou Ayiou Mina
		CY_8-8-c_RIh_HM	Potamos tou Ayiou Mina
		CY_8-8-d_RE_HM	Potamos tou Ayiou Mina
169	CY_8-9-1_R3	CY_8-9-a_RI	Vasilikos

AA	Water Body code 1st RBMP	Water Body code	Stream/reach name
170	CY_8-9-1_R3-HM	CY_8-9-b_RI_HM	Vasilikos
171	CY_8-9-2_R3	CY_8-9-c_RI	Vasilikos
		CY_8-9-g_RIh	Exovounia
172	CY_8-9-5_R3	NONE	
173	CY_8-9-5_R3-HM	CY_8-9-e_RI_HM	Vasilikos
		CY_8-9-f_RIh_HM	Vasilikos
174	CY_9-1-4_R3	CY_9-1-b_RIh	Argaki tou Pyrgou
		CY_9-1-c_RE	Argaki tou Pyrgou
		CY_9-1-d_RE	Argaki tou Pyrgou
175	CY_9-2-1_R2-HM	CY_9-2-d_RI_HM	Potamos tis Yermasogeias
176	CY_9-2-11_R2	CY_9-2-c_RI	Potamos tis Yermasogeias
177	CY_9-2-12_R2	NONE	
178	CY_9-2-2_R2	CY_9-2-a_RI	Karydhaki
		CY_9-2-e_RI	Potamos tis Yermasogeias
179	CY_9-2-31_R3	CY_9-2-e_RI	Potamos tis Yermasogeias
		CY_9-2-f_RI	Potamos tis Yermasogeias
180	CY_9-2-32_R3	CY_9-2-i_RIh	Argaki Pissokamina
181	CY_9-2-4_R2	CY_9-2-j_RI	Yialiadhes
		CY_9-2-k_RI	Yialiadhes
182	CY_9-2-4_R3-HM	CY_9-2-L_RI_HM	Yialiadhes
183	CY_9-2-5_R3-HM	CY_9-2-h_RIh_HM	Potamos tis Yermasogeias
184	CY_9-4-1_R3	CY_9-4-b_RI	Garyllis
		CY_9-4-c_RI	Garyllis
185	CY_9-4-3_R3	NONE	
186	CY_9-4-41_R3-HM	CY_9-4-e_RIh_HM	Garyllis
187	CY_9-4-42_R3-HM	CY_9-4-a_RE_HM	Vathias
		CY_9-4-f_RE_HM	Garyllis
188	CY_9-5-1_R3	CY_9-5-a_RE	Ypsonas
189	CY_9-6-1_R2	CY_9-6-p_RP	Kryos
190	CY_9-6-1_R2-HM	CY_9-6-q_RP_HM	Kryos
191	CY_9-6-1_R3-HM	CY_9-6-q_RP_HM	Kryos
		CY_9-6-r_RI_HM	Kryos
192	CY_9-6-2_R3	NONE	
193	CY_9-6-22_R3	NONE	
194	CY_9-6-31_R3	CY_9-6-L_RP	Kouris
195	CY_9-6-33_R3	CY_9-6-i_RP	Loumata
196	CY_9-6-33_R3-HM	CY_9-6-k_RP_HM	Loumata
197	CY_9-6-34_R3	NONE	
198	CY_9-6-35_R3	CY_9-6-n_RP	Mesapotamos
199	CY_9-6-36_R3	CY_9-6-o_RP	Moniatis
200	CY_9-6-4_R3-HM	CY_9-6-m_RP_HM	Kouris
201	CY_9-6-5_R2	CY_9-6-b_RP	Ambelikos-Agros
		CY_9-6-e_RP	Ambelikos-Xylourikos
202	CY_9-6-51_R2	CY_9-6-b_RP	Ambelikos-Agros
203	CY_9-6-52_R2	CY_9-6-a_RP	Ayios Ioannis

AA	Water Body code 1st RBMP	Water Body code	Stream/reach name
		CY_9-6-b_RP	Ambelikos-Agros
204	CY_9-6-53_R2	CY_9-6-c_RP	
205	CY_9-6-53_R2-HM	CY_9-6-d_RP_HM	
206	CY_9-6-71_R3	NONE	
207	CY_9-6-72_R3	CY_9-6-e_RP	Ambelikos-Xylourikos
		CY_9-6-f_RI	Potamos tou Limnati
208	CY_9-6-8_R3-HM	CY_9-6-w_RE_HM	Tapakhna
209	CY_9-6-81_R3	CY_9-6-u_RE	Batsounis
210	CY_9-6-82_R3	CY_9-6-v_RE	Tapakhna
211	CY_9-6-9_R3-HM	CY_9-6-t_RI_HM	Kouris
212	CY_9-7-1_R1	CY_9-7-b_RE	Symvoulas
213	CY_9-7-2_R1-HM	CY_9-7-c_RE_HM	Symvoulas
214	CY_9-8-1_R3	CY_9-8-a_RIh	Potamos tou Paramaliou
215	CY_9-8-4_R3	CY_9-8-b_RI	Evdhimou (Mandalas)
		CY_9-8-c_RIh	Evdhimou
216	CY_9-9-3_R1	CY_9-9-a_RE	Villourka

Appendix 15 List of river water bodies of the 2nd RBMP, pressure levels for each of the three pressure characteristics and combined pressure levels. The table does not include impounded rivers (i.e. water reservoirs).

AA	Water Body code	River name	River type	Pressure levels of pressure characteristics			Combined pressure level – Assessment group
				Population density	Areas of "intensive agriculture"	Livestock annual Nitrogen load	
1	CY_1-1-a_RP	Khapotami	P	significant	significant	significant	P-important
2	CY_1-1-b_RI	Khapotami	I	minor	significant	significant	I-important
3	CY_1-1-c_RIh	Khapotami	Ih	unknown	minor	minor	Ih-minor
4	CY_1-1-d_RIh_HM	Khapotami	Ih	none	none	none	E-negligible
5	CY_1-1-e_RI	Malleta	I	significant	significant	minor	I-important
6	CY_1-2-a_RP	Dhiarizos	P	minor	minor	minor	P-minor
7	CY_1-2-b_RP	Dhiarizos	P	minor	minor	none	P-minor
8	CY_1-2-d_RI_HM	Dhiarizos	I	unknown	significant	significant	Ih-important
9	CY_1-2-e_RI	Tholo Potamos	I	none	minor	none	I-minor
10	CY_1-2-f_RIh	Yerovasinos Potamos	Ih	unknown	minor	minor	Ih-minor
11	CY_1-3-a_RP	Argaki tis Roudhias	P	none	minor	none	P-negligible
12	CY_1-3-b_RI	Xeros Potamos	I	minor	minor	significant	I-minor
13	CY_1-3-c_RIh	Xeros Potamos	Ih	unknown	minor	minor	Ih-minor
14	CY_1-3-e_RE_HM	Xeros Potamos	E	none	unknown	minor	E-minor
15	CY_1-3-f_RI	Argaki Lazaridhaes	I	none	none	none	I-negligible
16	CY_1-3-g_RIh	Argaki ton Lefkarkon	Ih	unknown	minor	minor	Ih-minor
17	CY_1-4-a_RP	Ayia & Klimadhiou	P	none	none	none	P-negligible
18	CY_1-4-b_RI	Argaki tis Ayias	I	none	none	none	I-negligible
19	CY_1-4-d_RI_HM	Potamos tis Ezousas	I	unknown	minor	significant	Ih-important
20	CY_1-4-e_RIh_HM	Potamos tis Ezousas	Ih	unknown	significant	significant	Ih-important
21	CY_1-4-f_RP_HM	Potamos tis Ezousas	P	none	significant	significant	P-minor
22	CY_1-4-g_RI_HM	Potamos tis Ezousas	I	minor	minor	significant	I-minor
23	CY_1-4-h_RIh_HM	Potamos tis Ezousas	Ih	minor	unknown	minor	E-minor
24	CY_1-4-i_RI	Argaki tou Paleomylou	I	significant	minor	minor	I-minor

AA	Water Body code	River name	River type	Pressure levels of pressure characteristics			Combined pressure level – Assessment group
				Population density	Areas of “intensive agriculture”	Livestock annual Nitrogen load	
25	CY_1-4-j_RIh	Argakin tou Ayiou Nepiou	Ih	unknown	significant	significant	Ih-important
26	CY_1-4-k_RIh	Varkas	Ih	unknown	significant	significant	Ih-important
27	CY_1-4-L_RIh	Milarkou Potamos	Ih	unknown	minor	minor	Ih-minor
28	CY_1-4-m_RIh	Kochatis	Ih	unknown	significant	significant	Ih-important
29	CY_1-5-a_RE	Limnarka	E	minor	unknown	minor	E-minor
30	CY_1-5-b_RE_HM	Limnarka	E	minor	unknown	minor	E-minor
31	CY_1-5-c_RE	Kochinas	E	minor	unknown	minor	E-minor
32	CY_1-5-d_RE_HM	Kochinas	E	significant	unknown	minor	E-minor
33	CY_1-5-e_RE	Agriokalami	E	minor	unknown	minor	E-minor
34	CY_1-6-a_RIh	Mavrokolymbos	Ih	unknown	minor	minor	Ih-minor
35	CY_1-6-c_RIh_HM	Mavrokolymbos	Ih	none	unknown	minor	E-minor
36	CY_1-6-d_RIh	Xeros	Ih	unknown	minor	significant	Ih-minor
37	CY_1-8-a_RIh	Kalamouli (Avgas)	Ih	unknown	minor	minor	Ih-minor
38	CY_1-8-b_RIh	Pevkos Potamos	Ih	none	minor	minor	Ih-minor
39	CY_2-1-a_RE	Argaki tou Ayiou Ioanni	E	minor	unknown	significant	E-important
40	CY_2-2-a_RIh	Neraidhes & Potamos Ammadhkiou	Ih	unknown	significant	minor	Ih-important
41	CY_2-2-b_RI	Garillis Potamos	I	minor	significant	significant	I-important
42	CY_2-2-c_RI	Potamos tou Stavrou tis Psokas	I	none	minor	minor	I-minor
43	CY_2-2-d_RI	Potamos tou Stavrou tis Psokas	I	minor	significant	significant	I-important
44	CY_2-2-f_RI_HM	Potamos tou Stavrou tis Psokas	I	unknown	significant	significant	Ih-important
45	CY_2-2-g_RI_HM	Khrysokhou Potamos	I	significant	significant	significant	I-important
46	CY_2-2-h_RIh_HM	Khrysokhou Potamos	Ih	minor	unknown	minor	E-minor
47	CY_2-3-a_RIh	Mirmikoph	Ih	unknown	significant	significant	Ih-important
48	CY_2-3-b_RIh	Argaki tis Limnis	Ih	unknown	significant	none	Ih-important
49	CY_2-3-c_RI	Potamos tis Magoundas	I	minor	minor	none	I-minor
50	CY_2-3-d_RIh_HM	Potamos tis Magoundas	Ih	minor	unknown	minor	E-minor
51	CY_2-3-e_RE	Xeropotamos	E	none	unknown	minor	E-minor

AA	Water Body code	River name	River type	Pressure levels of pressure characteristics			Combined pressure level – Assessment group
				Population density	Areas of “intensive agriculture”	Livestock annual Nitrogen load	
52	CY_2-3-f_RP	Yialias Potamos	P	minor	minor	none	P-minor
53	CY_2-3-g_RI	Yialias Potamos	I	minor	significant	none	I-minor
54	CY_2-4-a_RIh	Xeros	Ih	none	none	none	Ih-negligible
55	CY_2-4-b_RIh_HM	Xeros	Ih	minor	unknown	none	E-minor
56	CY_2-4-c_RP	Maroti & Diali	P	none	none	none	P-negligible
57	CY_2-4-d_RI	Livadhi	I	none	none	none	I-negligible
58	CY_2-4-e_RIh_HM	Livadhi	Ih	unknown	minor	minor	Ih-minor
59	CY_2-5-a_RIh	Ayios Theodoros	Ih	unknown	minor	significant	Ih-minor
60	CY_2-6-a_RIh	Katouris	Ih	none	none	none	Ih-negligible
61	CY_2-6-b_RIh_HM	Katouris	Ih	unknown	minor	minor	Ih-minor
62	CY_2-7-a_RI	Potamos tou Pyrgou	I	minor	minor	none	I-minor
63	CY_2-8-a_RP	Potamos tou Limniti	P	none	none	none	P-negligible
64	CY_2-8-b_RI	Potamos tou Limniti	I	none	minor	none	None-occupied
65	CY_2-9-a_RI	Potamos tou Kambou	I	significant	significant	none	I-minor
66	CY_2-9-b_RP	Potamos tou Kambou	P	minor	minor	none	P-minor
67	CY_2-9-c_RI	Potamos tou Kambou	I	none	none	none	I-negligible
68	CY_2-9-d_RIh_HM	Potamos tou Kambou	Ih	none	none	none	Ih-negligible
69	CY_2-9-e_RE_HM	Potamos tou Kambou	E	none	unknown	none	None-occupied
70	CY_3-1-a_RP	Xeros	P	none	none	none	P-negligible
71	CY_3-1-b_RI	Xeros	I	none	none	none	I-negligible
72	CY_3-1-c_RI_HM	Xeros	I	none	none	none	I-negligible
73	CY_3-1-d_RIh_HM	Xeros	Ih	none	significant	none	None-occupied
74	CY_3-2-a_RP	Marathasa	P	significant	minor	none	P-minor
75	CY_3-2-b_RP_HM	Marathasa	P	minor	minor	minor	P-minor
76	CY_3-2-c_RI_HM	Setrakhos	I	none	significant	none	None-occupied
77	CY_3-2-d_RI	Rkondas	I	minor	minor	none	I-minor
78	CY_3-2-e_RE	Vrountokremni Argakin	E	none	none	none	E-negligible

AA	Water Body code	River name	River type	Pressure levels of pressure characteristics			Combined pressure level – Assessment group
				Population density	Areas of "intensive agriculture"	Livestock annual Nitrogen load	
79	CY_3-3-a_RP	Ayios Nikolaos	P	none	none	none	P-negligible
80	CY_3-3-b_RP	Karyiotis	P	significant	significant	significant	P-important
81	CY_3-3-c_RI	Karyiotis	I	significant	significant	significant	I-important
82	CY_3-3-d_RP	Argaki tou Karvouna	P	significant	minor	significant	P-important
83	CY_3-3-e_RI	Alykhnos	I	minor	minor	none	I-minor
84	CY_3-4-a_RI	Atsas	I	minor	minor	none	I-minor
85	CY_3-4-b_RIh	Atsas	Ih	unknown	significant	significant	Ih-important
86	CY_3-4-c_RIh_HM	Atsas	Ih	unknown	significant	significant	Ih-important
87	CY_3-4-d_RE_HM	Atsas	E	none	unknown	none	None-occupied
88	CY_3-5-a_RI	Lagoudhera	I	minor	minor	minor	I-minor
89	CY_3-5-c_RI_HM	Lagoudhera	I	unknown	minor	minor	Ih-minor
90	CY_3-5-d_RIh_HM	Potamos tis Elias	Ih	unknown	significant	significant	Ih-important
91	CY_3-5-e_RI	Kannavia	I	minor	minor	minor	I-minor
92	CY_3-5-f_RI	Asinou	I	minor	minor	minor	I-minor
93	CY_3-5-g_RE	Galouropniktis Potamos	E	none	unknown	minor	E-minor
94	CY_3-6-a_RE	Xeropotamos	E	minor	none	none	E-minor
95	CY_3-6-b_RE	Potami	E	minor	unknown	minor	E-minor
96	CY_3-6-c_RE	Komitis	E	minor	unknown	significant	E-important
97	CY_3-7-a_RI	Peristerona	I	significant	minor	minor	I-minor
98	CY_3-7-b_RIh	Peristerona	Ih	unknown	significant	significant	Ih-important
99	CY_3-7-c_RE	Peristerona	E	minor	unknown	significant	E-minor
100	CY_3-7-d_RI	Maroullenas	I	minor	minor	minor	I-minor
101	CY_3-7-e_RI	Kambi	I	significant	significant	minor	I-important
102	CY_3-7-f_RI_HM	Maroullenas	I	significant	minor	minor	I-minor
103	CY_3-7-g_RI	Pharmakas	I	significant	minor	minor	I-minor
104	CY_3-7-h_RI_HM	Pharmakas	I	none	significant	minor	I-minor
105	CY_3-7-j_RIh_HM	Potamos tou Akakiou	Ih	unknown	significant	significant	Ih-important

AA	Water Body code	River name	River type	Pressure levels of pressure characteristics			Combined pressure level – Assessment group
				Population density	Areas of "intensive agriculture"	Livestock annual Nitrogen load	
106	CY_3-7-k_RE_HM	Potamos tou Akakiou	E	minor	unknown	significant	E-important
107	CY_3-7-L_RE	Korivas	E	minor	unknown	minor	E-minor
108	CY_3-7-m_RE	Likythia	E	minor	unknown	minor	E-minor
109	CY_3-7-n_RIh	Koutis & Aloupos	Ih	unknown	minor	significant	Ih-minor
110	CY_3-7-o_RE	Merika	E	minor	unknown	significant	E-minor
111	CY_3-7-p_RE	Kokkinitrimithia	E	minor	unknown	minor	E-minor
112	CY_3-7-q_RE_HM	Serrakhis	E	minor	unknown	minor	None-occupied
113	CY_3-7-r_RE	Ovgos	E	minor	unknown	significant	E-minor
114	CY_3-7-s_R	Ovgos	Occupied				
115	CY_6-1-a_RIh	Pedhieos & Ayios Onouphrios	Ih	unknown	minor	minor	Ih-minor
116	CY_6-1-c_RIh_HM	Pedhieos	Ih	none	none	significant	Ih-important
117	CY_6-1-d_RE_HM	Pedhieos	E	significant	unknown	minor	E-minor
118	CY_6-1-e_RE_HM	Pedhieos	E	significant	none	none	E-important
119	CY_6-1-f_R	Pedhieos	Occupied				
120	CY_6-1-g_RE	Kouphos	E	minor	none	minor	E-minor
121	CY_6-1-h_RE	Argaki	E	minor	unknown	minor	E-minor
122	CY_6-1-i_RE	Klemos	E	minor	unknown	none	E-minor
123	CY_6-1-j_RE_HM	Klemos	E	significant	unknown	none	E-important
124	CY_6-1-k_RE_HM	Katevas	E	significant	none	none	E-important
125	CY_6-1-L_RE	Kaloyeros	E	significant	unknown	significant	E-important
126	CY_6-1-m_RE_HM	Vathys	E	significant	unknown	significant	E-minor
127	CY_6-1-n_RE_HM	Dhrakondias	E	significant	none	minor	E-minor
128	CY_6-1-o_RE	Vyzakotos	E	significant	unknown	minor	E-minor
129	CY_6-1-p_RE	Almyros	E	minor	unknown	minor	E-minor
130	CY_6-5-a_RIh	Yialias	Ih	unknown	none	significant	Ih-minor
131	CY_6-5-b_RI	Yialias	I	significant	minor	significant	I-important
132	CY_6-5-c_RE	Yialias	E	minor	unknown	significant	E-important

AA	Water Body code	River name	River type	Pressure levels of pressure characteristics			Combined pressure level – Assessment group
				Population density	Areas of "intensive agriculture"	Livestock annual Nitrogen load	
133	CY_6-5-d_R	Yialias	Occupied				
134	CY_6-5-e_RIh	Koutsos	Ih	unknown	minor	significant	Ih-minor
135	CY_6-5-f_RIh_HM	Koutsos	Ih	unknown	minor	significant	Ih-important
136	CY_6-5-g_RE	Argaki ton Villourkon	E	minor	unknown	minor	E-minor
137	CY_6-5-h_RE	Alykos	E	minor	unknown	significant	E-important
138	CY_6-5-i_RE	Almyros	E	minor	none	minor	E-minor
139	CY_7-2-a_RIh	Vathys	Ih	unknown	minor	minor	Ih-minor
140	CY_7-2-b_RE	Liopetri	E	minor	unknown	minor	E-minor
141	CY_7-2-c_RE_HM	Liopetri	E	minor	unknown	minor	E-minor
142	CY_8-1-a_RE	Avdellero	E	minor	unknown	minor	E-minor
143	CY_8-1-b_RE_HM	Avdellero	E	minor	unknown	significant	E-important
144	CY_8-2-a_RE	Aradippou	E	minor	unknown	significant	E-important
145	CY_8-2-b_RE_HM	Aradippou	E	minor	unknown	significant	E-important
146	CY_8-3-a_RE	Kalo Chorio	E	minor	unknown	significant	E-minor
147	CY_8-3-b_RE		E	minor	unknown	significant	E-important
148	CY_8-4-a_RE	Ammos & Kalamoulia	E	minor	unknown	minor	E-minor
149	CY_8-4-b_RE	Xylias	E	minor	unknown	minor	E-minor
150	CY_8-4-c_RE_HM	Tremithos	E	minor	unknown	significant	E-important
151	CY_8-4-d_RE_HM	Tremithos	E	minor	unknown	minor	E-minor
152	CY_8-4-e_RE	Ayia Marina	E	minor	unknown	significant	E-minor
153	CY_8-4-f_RE	Mosfiloti	E	minor	unknown	minor	E-minor
154	CY_8-4-g_RE	Ayios Ioannis	E	minor	unknown	minor	E-minor
155	CY_8-5-a_RIh	Pouzis	Ih	unknown	minor	minor	Ih-minor
156	CY_8-5-b_RE	Pouzis	E	minor	unknown	significant	E-minor
157	CY_8-5-c_RE	Xeropouzos	E	minor	unknown	minor	E-minor
158	CY_8-6-a_RIh	Xeropotamos	Ih	unknown	minor	significant	Ih-important
159	CY_8-7-a_RI	Syrkatis	I	none	minor	minor	I-minor

AA	Water Body code	River name	River type	Pressure levels of pressure characteristics			Combined pressure level – Assessment group
				Population density	Areas of “intensive agriculture”	Livestock annual Nitrogen load	
160	CY_8-7-c_RI_HM	Syrkatis	I	unknown	significant	minor	Ih-important
161	CY_8-7-d_RIh	Argaki tou Mylou	Ih	unknown	minor	minor	Ih-minor
162	CY_8-7-f_RI_HM	Pendaskhinos	I	minor	unknown	significant	E-minor
163	CY_8-7-g_RIh_HM	Pendaskhinos	Ih	minor	unknown	significant	E-important
164	CY_8-7-h_RE		E	none	unknown	minor	E-minor
165	CY_8-8-a_RI	Potamos tou Ayiou Mina	I	minor	significant	minor	I-minor
166	CY_8-8-b_RIh	Potamos tou Ayiou Mina	Ih	unknown	minor	minor	Ih-minor
167	CY_8-8-c_RIh_HM	Potamos tou Ayiou Mina	Ih	unknown	minor	significant	Ih-minor
168	CY_8-8-d_RE_HM	Potamos tou Ayiou Mina	E	minor	unknown	minor	E-minor
169	CY_8-9-a_RI	Vasilikos	I	minor	significant	none	I-minor
170	CY_8-9-b_RI_HM	Vasilikos	I	none	significant	minor	I-minor
171	CY_8-9-c_RI	Vasilikos	I	significant	significant	minor	I-important
172	CY_8-9-e_RI_HM	Vasilikos	I	minor	unknown	minor	E-minor
173	CY_8-9-f_RIh_HM	Vasilikos	Ih	minor	unknown	significant	E-important
174	CY_8-9-g_RIh	Exovounia	Ih	unknown	significant	none	Ih-important
175	CY_8-9-h_RIh	Argaki tis Asgatas	Ih	unknown	minor	minor	Ih-minor
176	CY_9-1-a_RE	Pendakomo	E	minor	unknown	minor	E-minor
177	CY_9-1-b_RIh	Argaki tou Pyrgou	Ih	unknown	significant	minor	Ih-important
178	CY_9-1-c_RE	Argaki tou Pyrgou	E	minor	unknown	minor	E-minor
179	CY_9-1-d_RE	Argaki tou Pyrgou	E	minor	unknown	minor	E-minor
180	CY_9-1-e_RE	Argaki tis Monis	E	minor	unknown	significant	E-important
181	CY_9-2-a_RI	Karydhaki	I	minor	minor	minor	I-minor
182	CY_9-2-b_RP	Ayios Pavlos	P	minor	minor	significant	P-important
183	CY_9-2-c_RI	Potamos tis Yermasogeias	I	significant	significant	minor	I-important
184	CY_9-2-d_RI_HM	Potamos tis Yermasogeias	I	significant	significant	minor	I-important
185	CY_9-2-e_RI	Potamos tis Yermasogeias	I	significant	significant	minor	I-important
186	CY_9-2-f_RI	Potamos tis Yermasogeias	I	none	minor	minor	I-minor

AA	Water Body code	River name	River type	Pressure levels of pressure characteristics			Combined pressure level – Assessment group
				Population density	Areas of "intensive agriculture"	Livestock annual Nitrogen load	
187	CY_9-2-h_RIh_HM	Potamos tis Yermasogeias	Ih	unknown	minor	significant	Ih-minor
188	CY_9-2-i_RIh	Argaki Pissokamina	Ih	unknown	significant	minor	Ih-important
189	CY_9-2-j_RI	Yialiadhes	I	none	none	none	I-negligible
190	CY_9-2-k_RI	Yialiadhes	I	minor	significant	minor	I-minor
191	CY_9-2-L_RI_HM	Yialiadhes	I	significant	minor	significant	I-important
192	CY_9-3-a_RE	Vathias (Ag. Athanasios)	E	minor	unknown	minor	E-minor
193	CY_9-3-b_RE_HM	Vathias (Ag. Athanasios)	E	significant	none	minor	E-important
194	CY_9-4-a_RE_HM	Vathias	E	significant	none	minor	E-important
195	CY_9-4-b_RI	Garyllis	I	significant	minor	minor	I-minor
196	CY_9-4-c_RI	Garyllis	I	minor	significant	significant	I-important
197	CY_9-4-e_RIh_HM	Garyllis	Ih	significant	unknown	significant	E-important
198	CY_9-4-f_RE_HM	Garyllis	E	significant	unknown	none	E-important
199	CY_9-4-g_RIh	Phasoula	Ih	unknown	significant	minor	Ih-important
200	CY_9-5-a_RE	Ypsonas	E	minor	unknown	none	E-minor
201	CY_9-6-a_RP	Ayios Ioannis	P	significant	significant	significant	P-important
202	CY_9-6-b_RP	Ambelikos-Agros	P	significant	significant	significant	P-important
203	CY_9-6-c_RP		P	none	significant	none	P-minor
204	CY_9-6-d_RP_HM		P	significant	significant	none	P-minor
205	CY_9-6-e_RP	Ambelikos-Xylourikos	P	minor	significant	minor	P-important
206	CY_9-6-f_RI	Potamos tou Limnati	I	significant	significant	significant	I-important
207	CY_9-6-g_RI	Pelendri	I	significant	minor	minor	I-minor
208	CY_9-6-h_RI	Ayios Mamas	I	minor	minor	minor	I-minor
209	CY_9-6-i_RP	Loumata	P	none	none	none	P-negligible
210	CY_9-6-k_RP_HM	Loumata	P	minor	none	none	P-negligible
211	CY_9-6-L_RP	Kouris	P	minor	significant	significant	P-important
212	CY_9-6-m_RP_HM	Kouris	P	significant	significant	significant	P-important
213	CY_9-6-n_RP	Mesapotamos	P	minor	none	none	P-negligible

AA	Water Body code	River name	River type	Pressure levels of pressure characteristics			Combined pressure level – Assessment group
				Population density	Areas of "intensive agriculture"	Livestock annual Nitrogen load	
214	CY_9-6-o_RP	Moniatis	P	significant	minor	significant	P-important
215	CY_9-6-p_RP	Kryos	P	significant	minor	none	P-minor
216	CY_9-6-q_RP_HM	Kryos	P	significant	minor	none	P-minor
217	CY_9-6-r_RI_HM	Kryos	I	unknown	minor	minor	Ih-minor
218	CY_9-6-t_RI_HM	Kouris	I	unknown	minor	significant	Ih-important
219	CY_9-6-u_RE	Batsounis	E	minor	unknown	significant	E-important
220	CY_9-6-v_RE	Tapakhna	E	minor	unknown	minor	E-minor
221	CY_9-6-w_RE_HM	Tapakhna	E	minor	unknown	minor	E-minor
222	CY_9-7-a_RE	Krommya	E	minor	unknown	minor	E-minor
223	CY_9-7-b_RE	Symvoulas	E	minor	unknown	minor	E-minor
224	CY_9-7-c_RE_HM	Symvoulas	E	minor	unknown	minor	E-minor
225	CY_9-8-a_RIh	Potamos tou Paramaliou	Ih	unknown	significant	minor	Ih-important
226	CY_9-8-b_RI	Evdhimou (Mandalas)	I	significant	significant	significant	I-important
227	CY_9-8-c_RIh	Evdhimou	Ih	unknown	minor	significant	Ih-important
228	CY_9-8-d_RE	Pantijo	E	minor	unknown	significant	E-important
229	CY_9-8-e_RE	Argaki Paleomylos	E	minor	unknown	minor	E-minor
230	CY_9-9-a_RE	Villourka	E	minor	unknown	minor	E-minor

Appendix 16 Monitoring stations of assessment groups

River type: P

Pressure level: negligible

Monitoring stations:

Water body code	Station code	Station name
CY_1-3-a_RP	r1-3-5-05	Argaki tis Roudhias-Lazaridhes
CY_1-3-a_RP	r1-3-5-91	Argaki tis Roudhias-Rhoudias bridge
CY_2-8-a_RP	r2-8-3-10	Potamos tou Limniti-Saw Mill
CY_3-3-a_RP	r3-3-1-60	Ayios Nikolaos-u/s Fish Farm
CY_9-6-i_RP	r9-6-3-15	Loumata-u/s Loumata pond

The following station will also be used for the “P negligible” assessment group; it is located in the upper reach of water body CY_2-3-f_RP with negligible pressures; pressures on this water body are located further downstream.

Water body code	Station code	Station name
CY_2-3-f_RP	r2-3-8-48	Yialias Potamos-Pochalandra

River type: P

Pressure level: minor

Monitoring stations:

Water body code	Station code	Station name
CY_1-2-a_RP	r1-2-4-25	Dhiarizos-u/s Arminou Dam
CY_1-4-f_RP_HM	r1-4-5-73	Potamos tis Ezousas-Pitarkou
CY_1-4-f_RP_HM	r1-4-7-10	Potamos tis Ezousas-Moro Nero
CY_2-9-b_RP	r2-9-2-50	Potamos tou Kambou-Ag. Varvara
CY_3-2-a_RP	r3-2-1-85	Marathasa-
CY_9-6-p_RP	r9-6-1-44	Kryos-Mylomeris
CY_9-6-q_RP_HM	r9-6-1-87	Kryos-Koilani

River type: P

Pressure level: important

Monitoring stations:

Water body code	Station code	Station name
CY_3-3-b_RP	r3-3-3-27	Karyiotis-d/s Galata
CY_3-3-b_RP	r3-3-3-95	Karyiotis-Evrychou
CY_9-6-a_RP	r9-6-5-66	Ayios Ioannis-u/s Ag. Ioannis
CY_9-6-a_RP	r9-6-5-67	Ayios Ioannis-near Ag. Ioannis
CY_9-6-b_RP	r9-6-5-17	Ambelikos-Agros-Kyperounta
CY_9-6-b_RP	r9-6-5-53	Ambelikos-Agros-Potamitissa
CY_9-6-b_RP	r9-6-5-57	Ambelikos-Agros-d/s Perambeli confluence
CY_9-6-b_RP	r9-6-5-62	Ambelikos-Agros-near Ag. Ioannis
CY_9-6-b_RP	r9-6-5-69	Ambelikos-Agros-Kato Mylos Bridge
CY_9-6-b_RP	r9-6-5-74	Ambelikos-Agros-near Kato Mylos
CY_9-6-b_RP	r9-6-5-75	Ambelikos-Agros-near Kato Mylos
CY_9-6-e_RP	r9-6-6-32	Ambelikos-Xylourikos-Ag. Mamas
CY_9-6-e_RP	r9-6-6-93	Ambelikos-Xylourikos-near Kapileio
CY_9-6-L_RP	r9-6-3-36	Kouris-Kato Amiantos
CY_9-6-m_RP_HM	r9-6-4-92	Kouris-Alassa new weir

River type: I

Pressure level: negligible

Monitoring stations:

Water body code	Station code	Station name
CY_1-4-b_RI	r1-4-3-35	Argaki tis Ayias-u/s Kannaviou Dam
CY_2-4-d_RI	r2-4-6-65	Livadhi-
CY_3-1-b_RI	r3-1-2-30	Xeros-u/s Kafizes Dam
CY_9-2-j_RI	r9-2-4-27	Yialiadhes-Armyrou Monastiri

River type: I

Pressure level: minor

Monitoring stations:

Water body code	Station code	Station name
CY_1-3-b_RI	r1-3-6-53	Xeros Potamos-Rotsos ton Laoudion
CY_2-2-c_RI	r2-2-5-02	Potamos tou Stavrou tis Psokas-
CY_2-2-c_RI	r2-2-5-75	Potamos tou Stavrou tis Psokas-Rizokremmos
CY_2-3-c_RI	r2-3-4-80	Potamos tis Magoundas-
CY_2-7-a_RI	r2-7-2-75	Potamos tou Pyrgou-Phleva
CY_3-5-a_RI	r3-5-1-50	Lagoudhera-
CY_3-7-a_RI	r3-7-1-55	Peristerona-Siphilos
CY_3-7-f_RI_HM	r3-7-3-71	Maroullenas-u/s Akaki-Malounta Dam
CY_8-7-a_RI	r8-7-1-65	Syrkatis-Kyprovasa
CY_9-2-f_RI	r9-2-3-29	Potamos tis Yermasogeias-
CY_9-2-f_RI	r9-2-3-85	Potamos tis Yermasogeias-Phinikaria
CY_9-4-b_RI	r9-4-1-38	Garyllis-d/s Ay. Paraskevi, Kangelli
CY_9-4-b_RI	r9-4-1-63	Garyllis-u/s Gerasa Dhimmata locality
CY_9-4-b_RI	r9-4-1-93	Garyllis-near Tsangarou locality
CY_9-4-b_RI	r9-4-3-41	Garyllis-Paramytha

River type: I

Pressure level: important

Monitoring stations:

Water body code	Station code	Station name
CY_1-1-b_RI	r1-1-3-95	Khapotami-Kissousa
CY_2-2-b_RI	r2-2-3-95	Garillis Potamos-Skoulli
CY_2-2-d_RI	r2-2-6-24	Potamos tou Stavrou tis Psokas-
CY_6-5-b_RI	r6-5-1-85	Yialias-Kotsiatis
CY_8-9-c_RI	r8-9-5-40	Vasilikos-Layia
CY_9-2-e_RI	r9-2-3-05	Potamos tis Yermasogeias-Dierona
CY_9-2-L_RI_HM	r9-2-4-95	Yialiadhes-Akrounta
CY_9-6-f_RI	r9-6-7-29	Potamos tou Limnati-near Limnatis
CY_9-6-f_RI	r9-6-7-70	Potamos tou Limnati-u/s Kouris Dam
CY_1-1-b_RI	r1-1-3-95	Khapotami-Kissousa
CY_2-2-b_RI	r2-2-3-95	Garillis Potamos-Skoulli
CY_2-2-d_RI	r2-2-6-24	Potamos tou Stavrou tis Psokas-

The following stations are located on water body CY_9-4-c_RI of Garyllis River that is highly polluted from the Vati landfill site. The severity and the uniqueness in Cyprus of the impact of this point pollution source renders the stations unrepresentative of the group, and theywill not be used for the assessment of the unmonitored water bodies of the group:

Water body code	Station code	Station name
CY_9-4-c_RI	r9-4-3-80	Garyllis-u/s Polemidia Dam
CY_9-4-c_RI	r9-4-3-89	Garyllis-Dam inflow u/s, Atophoulies
CY_9-4-c_RI	r9-4-3-94	Garyllis-Dam inflow d/s, Koliokremmos

River type: Ih

Pressure level: negligible

There are no available monitoring stations for this assessment group

River type: Ih

Pressure level: minor

Monitoring stations:

Water body code	Station code	Station name
CY_1-1-c_RIh	r1-1-6-65	Khapotami-Kato Archimandrita
CY_1-3-c_RIh	r1-3-8-60	Xeros Potamos-Phinikas
CY_3-5-c_RI_HM	r3-5-4-40	Lagoudhera-Vizakia
CY_6-1-a_RIh	r6-1-1-48	Ag. Onoufrios
CY_6-1-a_RIh	r6-1-1-72	Pedhieos-
CY_6-1-a_RIh	r6-1-1-80	Ag. Onoufrios
CY_8-8-c_RIh_HM	r8-8-2-95	Potamos tou Ayiou Mina-Choirokoitia
CY_9-6-r_RI_HM	r9-6-2-60	Kryos-u/s Tunnel Outlet

River type: Ih

Pressure level: important

Monitoring stations:

Water body code	Station code	Station name
CY_1-2-d_RI_HM	r1-2-6-89	Dhiarizos @ Mamonia
CY_2-3-b_RIh	r2-3-2-96	Argaki tis Limnis-
CY_3-4-b_RIh	r3-4-2-90	Atsas-
CY_8-7-c_RI_HM	r8-7-2-60	Syrkatis-Pano Lefkara

River type: E

Pressure level: negligible

There are no available monitoring stations for this assessment group

River type: E

Pressure level: minor

Monitoring stations:

Water body code	Station code	Station name
CY_3-7-c_RE	r3-7-1-84	Peristerona-Peristerona
CY_3-7-L_RE	r3-7-2-93	Likythia-Akaki (no data)
CY_6-1-d_RE_HM	r6-1-2-38	Pedhieos-K. Deftera

River type: E

Pressure level: important

Monitoring stations:

Water body code	Station code	Station name
CY_6-1-e_RE_HM	r6-1-2-90	Pedhieos-Lefkosia
CY_6-1-L_RE	r6-1-5-52	Vathys-Athalassa
CY_6-5-c_RE	r6-5-3-15	Yialias-Nisou
CY_6-5-c_RE	r6-5-3-50	Yialias-Potamia
CY_8-4-c_RE_HM	r8-4-3-40	Tremithos-Ag. Anna
CY_8-4-c_RE_HM	r8-4-5-30	Tremithos-Klavdia

Appendix 17 Further discussion on ephemeral/episodic rivers as water bodies under the WFD

A further analysis of the need to delineate ephemeral/episodic rivers as water bodies under the WFD reveals the following arguments: For an element of surface water to be delineated as a water body, according to WFD Art.2.10 it has to be "a discrete and significant element of surface water". If one considers this requirement in addition to the size criterion adopted by this study, i.e. the catchment area threshold of $10km^2$, then the term "discrete and significant" has to be interpreted before its application to streams with a catchment area over $10km^2$. Such interpretation is given in WFD CIS Guidance Document 2: "Each water body should be identified on the basis of its "discreteness and significance" in the context of the Directive's purposes, objectives and provisions" (European Commission, 2003a, p.5). In other words, to decide whether an element of surface water should be delineated as a water body or not, the purposes, objectives and provisions pertinent to water bodies in the Directive need to be taken into account.

WFD Art.1a, for example, states that the <u>purpose</u> of the Directive is to establish a framework that "prevents further deterioration and protects and enhances the status of aquatic ecosystems and, with regard to their water needs, terrestrial ecosystems and wetlands directly depending on the aquatic ecosystems". If one now considers that terrestrial ecosystems, e.g. riparian corridors of terrestrial vegetation, along the course of ephemeral/episodic rivers have water needs that depend on these ephemeral/episodic rivers (Boulton, 2014, Jacobson et al., 1995, Kassas and Imam, 1954), then the latter become significant under the WFD; this line of argumentation is actually very close to the functioning of ephemeral rivers in Cyprus which, while not supporting WFD BQEs, support in many cases riparian corridors along their banks. With respect to the Directive's <u>objectives</u>, Art.4bii states that „Member States shall protect, enhance and restore all bodies of groundwater, ensure a balance between abstraction and recharge of groundwater". The undoubted fact that ephemeral/episodic rivers play an important role for the recharge of aquifers located along their course (Nadeau and Rains, 2007, Levick et al., 2008, Jacobson and Jacobson, 2013, Boulton, 2014) is thus another indication of the significance of these rivers, because they would have to be managed to ensure their role for recharging aquifers. With respect to Art.4c of the Directive, it is clear that ephemeral/episodic rivers play a role for the objectives in water related protected areas, e.g. Natura 2000 areas along river courses, and thus their significance in protected areas becomes evident.

Still, a counterargument to the above can be based on Guidance Document 2, which states: "The 'water body' should be a coherent sub-unit in the river basin (district) to which the environmental objectives of the directive must apply. Hence, the <u>*main purpose*</u> of identifying 'water bodies' is to enable the status to be accurately described and compared to environmental objectives" (European Commission, 2003a, p.2). Because status is determined by predefined BQEs and these do not exist in ephemeral/episodic rivers, one could argue that the main purpose of identifying "water bodies" cannot be achieved in these rivers and therefore they are not identified. However, with respect to the assessment of status in ephemeral streams, it is interesting to note that Reyjol et al. (2014), in their article that synthesises the recommendations for the most crucial research and development needs for enhancing WFD implementation with a view to the revision of the WFD in 2019, made specific mention that no methods are defined for ephemeral streams thus hinting that these streams should be assessed for WFD purposes; considering that the group of authors of this latter paper consists of a who-is-who of academics directly involved in assessing water systems under the WFD, it gains considerable weight and can be expected to have influence on the upcoming revision of the Directive. Still, apart from status assessment, there could also be *secondary purposes* of a water body as were mentioned further above, e.g. the role of rivers for the achievement of environmental objectives related to protected areas and groundwater bodies, and these may be sufficient to justify the identification of ephemeral/episodic rivers as water bodies.

Taking into account the above arguments, pro and contra an inclusion of ephemeral/episodic rivers as water bodies, leads to the conclusion that either decision can be interpreted as an indication of the efforts a Member State is willing to make for the protection of its waters.

Appendix 18 **Letter of the Acting Director of the Water Development Department to the researcher**

REPUBLIC OF CYPRUS
MINISTRY OF AGRICULTURE,
RURAL DEVELOPMENT AND ENVIRONMENT

WATER DEVELOPMENT
DEPARTMENT

WDD file no.: 07.01.01

Nicosia, January 26, 2016

Gerald Dörflinger, Hydrologist

Report on «Recommendations for the introduction of a new spatial basis of rivers monitoring and management for the implementation of the E.U. Water Framework Directive in Cyprus and investigation of the potential effects of their implementation»

I would like to thank you for the elaborative work you have submitted to the Water Development Department in the abovementioned report. I consider it as a high quality piece of work and I am happy that its outcome is already being successfully implemented by the Water Development Department. Beyond that, I am confident that this work will make a significant contribution to improved implementation of the E.U. Water Framework Directive in Cyprus and to river monitoring and management on the island in general.

ANDREAS MANOLIS
Acting Director

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Appendix 19 Memorandum of Understanding 2015 between the WDD and the State General Laboratory of Cyprus (SGL) for the analyses to be undertaken by SGL for WDD

(In Greek, with table A2 in English, 8 pages)

Purpose of the Memorandum in English:

"*This Memorandum of Understanding is aiming to the enacting of a mutually agreed framework of cooperation between the Water Development Department (WDD) and the State General Laboratory (SGL) for the implementation of the monitoring programme required by Article 8 of the Water Framework Directive (2000/60/EC, WFD) in Cyprus.*"

√05.26.001, 02.11.004.01

72

ΤΜΗΜΑ ΑΝΑΠΤΥΞΕΩΣ ΥΔΑΤΩΝ (ΤΑΥ)–ΓΕΝΙΚΟ ΧΗΜΕΙΟ ΤΟΥ ΚΡΑΤΟΥΣ (ΓΧΚ)

ΠΡΩΤΟΚΟΛΛΟ ΣΥΝΕΡΓΑΣΙΑΣ ΓΙΑ ΤΟ 2015

Εφαρμογή του προγράμματος παρακολούθησης που απαιτείται από το Άρθρο 8 της Οδηγίας Πλαίσιο Υδάτων (Ο.Π.Υ.) 2000/60/ΕΚ στην Κύπρο

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Εφαρμογή του προγράμματος παρακολούθησης που απαιτείται από το Άρθρο 8 της Οδηγίας Πλαίσιο Υδάτων (Ο.Π.Υ.) 2000/60/ΕΚ στην Κύπρο για το 2015

ΑΡΘΡΟ 1. ΣΚΟΠΟΣ ΤΟΥ ΠΡΩΤΟΚΟΛΛΟΥ

Το παρόν μέρος του πρωτόκολλου συνεργασίας στοχεύει στη θέσπιση ενός αμοιβαίως συμφωνηθέντος πλαισίου συνεργασίας μεταξύ του Τμήματος Αναπτύξεως Υδάτων (Τ.Α.Υ.) και του Γενικού Χημείου του Κράτους (Γ.Χ.Κ.) κατά τη διάρκεια της εφαρμογής του προγράμματος παρακολούθησης που απαιτείται από την Οδηγία Πλαίσιο Υδάτων (2000/60/ΕΚ, ΟΠΥ) - Άρθρο 8 - στην Κύπρο.

ΑΡΘΡΟ 2. ΓΕΝΙΚΕΣ ΑΡΧΕΣ

2.1 Το παρόν μέρος του πρωτόκολλου συνεργασίας αντικατοπτρίζει τη σταδιακή εξέλιξη της παρακολούθησης των υδάτων στα πλαίσια της εφαρμογής του Άρθρου 8 της ΟΠΥ από το 2007 μέχρι το 2015, και πιο συγκεκριμένα:

i. Τα περιεχόμενα της Τελικής Έκθεσης της Δράσης 2.4 και του Σχεδίου Δράσης (Action Plan) του έργου "Ανάπτυξη ενός Ολοκληρωμένου Προγράμματος Παρακολούθησης των Υδάτων και Ανάπτυξη σχετικής βάσης δεδομένων υποστήριξης της εφαρμογής της Οδηγίας Πλαίσιο Υδάτων 2000/60/ΕΕ στην Κύπρο, Σύμβαση Νο. 46/2005" όπως εγκρίθηκε από τη Συντονιστική Επιτροπή του έργου στις 17/07/2007.

ii. Την αξιολόγηση των αποτελεσμάτων του προγράμματος παρακολούθησης για τα επιφανειακά νερά στο πλαίσιο του Άρθρου 8 της ΟΠΥ για τα έτη 2007-2009, η οποία έγινε από συμβούλους στα πλαίσια της Σύμβασης ΤΑΥ54/2009 και από λειτουργούς του ΤΑΥ και του ΓΧΚ. Ως αποτέλεσμα της εν λόγω αξιολόγησης, το πρόγραμμα παρακολούθησης είχε αναθεωρηθεί και το αναθεωρημένο πρόγραμμα αποτελούσε τη βάση για το Πρωτόκολλο Συνεργασίας ΤΑΥ-ΓΧΚ για το 2010.

iii. Την τροποποίηση του Πρωτόκολλου Συνεργασίας τον Απρίλιο 2011, με την οποία προστέθηκαν οι ταμιευτήρες νερού Μαυροκόλυμπος και Ξυλιάτος, οι οποίοι είναι δηλωμένοι στην Ε.Ε. ως υδάτινα σώματα της ΟΠΥ, και μειώθηκε ο αριθμός των δειγμάτων από ορισμένους άλλους ταμιευτήρες νερού.

iv. Την προκαταρκτική αξιολόγηση των αποτελεσμάτων του προγράμματος παρακολούθησης του 2011, τα οποία υπέδειξαν την αναγκαιότητα μιας μικρής προσαρμογής στο πρόγραμμα παρακολούθησης των ποταμών, χωρίς όμως να επηρεάσει το συνολικό αριθμό δειγμάτων του προγράμματος. Το προσαρμοσμένο πρόγραμμα αποτελούσε τη βάση για το Πρωτόκολλο Συνεργασίας ΤΑΥ-ΓΧΚ για το 2012.

v. Την προκαταρκτική αξιολόγηση των αποτελεσμάτων του προγράμματος παρακολούθησης για τα επιφανειακά νερά στο πλαίσιο του Άρθρου 8 της ΟΠΥ για τα έτη 2009-2012, η οποία έγινε από το ΤΑΥ με σκοπό την προσαρμογή του προγράμματος παρακολούθησης αφενός στις εισηγήσεις του Προγράμματος Μέτρων της ΟΠΥ και, αφετέρου, για το 3° Σχέδιο Διαχείρισης Λεκανών Απορροής, χωρίς όμως να επηρεαστεί σημαντικά ο συνολικός αριθμός δειγμάτων του προγράμματος.

vi. Την μελέτη για την «ετοιμασία καταλόγου εκπομπών, απορρίψεων και διαρροών» για τις ουσίες της Οδηγίας 2008/105/ΕΚ που εκπονήθηκε από την εταιρεία I.A.CO Ltd. για λογαριασμό του Τμ. Περιβάλλοντος στα πλαίσια της Σύμβασης 14/2012 και πιο συγκεκριμένα τις περιοχές υψηλής συγκέντρωσης πηγών ρύπανσης «hotspots» που αναφέρονται σε αυτήν (Πιν.4.2-16).

vii. Τις υποχρεώσεις που απορρέουν από την Οδηγία 2008/105/ΕΚ και την αναθεωρημένη Οδηγία 2013/39/ΕΕ.

viii. Τις παρατηρήσεις της Ευρωπαϊκής Επιτροπής στο 1° ΣΔΛΑΠ της Κύπρου οι οποίες λήφθηκαν από το ΤΑΥ κατά το 2012 και 2013, και το σχετικό Σχέδιο Δράσης (Action Plan) που η Κύπρος δεσμεύθηκε να υλοποιήσει.

ix. Την αξιολόγηση των αποτελεσμάτων του προγράμματος παρακολούθησης για τα επιφανειακά νερά στο πλαίσιο του Άρθρου 8 της ΟΠΥ για τα έτη 2009-2013 η οποία έγινε από την εταιρεία I.A.CO Ltd. στα πλαίσια της Σύμβασης ΥΥ02/2013 με σκοπό την ετοιμασία της βάσης για την εκπόνηση του 2ου Σχεδίου Διαχείρισης Λεκανών Απορροής (ΣΔΛΑΠ).

71

x. Τα προκαταρκτικά αποτελέσματα της αναθεώρησης του Άρθρου 5 της ΟΠΥ και πιο συγκεκριμένα τις αλλαγές στους τύπους των ποταμών καθώς και την καινούργια ομαδοποίηση των υδάτινων σωμάτων για σκοπούς αξιολόγησης, που είχαν ληφθεί υπόψη για το πρωτόκολλο του 2014

xi. Τα τελικά αποτελέσματα της αναθεώρησης του Άρθρου 5 της ΟΠΥ και την αξιολόγηση των αποτελεσμάτων του προγράμματος παρακολούθησης για τα επιφανειακά νερά στο πλαίσιο του Άρθρου 8 της ΟΠΥ για τα έτη 2009-2013 η οποία έγινε από την εταιρεία I.A.CO Ltd. στα πλαίσια της Σύμβασης ΥΥ02/2013. Με βάση αυτά, έγινε μια ριζική αναθεώρηση του προγράμματος παρακολούθησης των ποταμών με σκοπό την εκμετάλλευση των δυνατοτήτων και ευκαιριών που προκύπτουν από:

a. το καινούργιο δίκτυο υδάτινων σωμάτων που είναι προσαρμοσμένος στις πιέσεις

b. την καινούργια τυπολογία που έιναι καθοριστική για την παρακολούθηση βιολογικών ποιοτικών στοιχείων ή μη

c. την καινούργια ομαδοποίηση των υδάτινων σωμάτων για σκοπούς αξιολόγησης που επιτρέπει: 1) την εκτίμηση του απαιτούμενου αριθμού σταθμών ανά τύπο ποταμού για επίτευξη πετυχημένης άσκησης ομαδοποίησης υδάτινων σωμάτων για το 3^{ο} ΣΔΛΑΠ, το 2019-2020, και 2) την στοχευμένη τοποθέτηση σταθμών για κάλυψη ολόκληρης της βαθμίδωσης των πιέσεων

d. τα αποτελέσματα όσον αφορά την αβεβαιότητα στην ταξινόμηση της κατάστασης των υδάτων που προδιορίσθηκαν στη σύμβαση ΥΥ02/2013 και που επιτρέπουν την εκτίμηση του απαιτούμενου αριθμού δειγμάτων ανά σταθμού για επίτευξη αποδεκτού επιπέδου βεβαιότητας στα αποτελέσματα της παρακολούθησης

~~xii.~~ Τη μελέτη για την «ετοιμασία καταλόγου εκπομπών, απορρίψεων και διαρροών» για τις ουσίες της Οδηγίας 2008/105/ΕΚ που εκπονήθηκε από την εταιρεία I.A.CO Ltd. για λογαριασμό του Τμ. Περιβάλλοντος στα πλαίσια της Σύμβασης 14/2012. Για το παρόν Πρωτόκολλο Συνεργασίας η εν λόγω μελέτη λήφθηκε εκ νέου υπόψη και ειδικά όσον αφορά τις περιοχές υψηλής συγκέντρωσης πηγών ρύπανσης «hotspots» (Πιν.4.2-16 της μελέτης) και τις συνάφειες των ουσιών προτεραιότητας ανά υπολεκάνη απορροής (Πιν. 5.7), τα οποία αξιολογήθηκαν σε σχέση με το αναθεωρημένο δίκτυου ποτάμιων υδάτινων σωμάτων.

xiii. Την έκθεση για την «Επικαιροποίηση του Άρθρου 5 της Οδηγίας 2000/60/ΕΚ ως προς την Επισκόπηση των Πιέσεων και Επιπτώσεων των Ανθρωπίνων Δραστηριοτήτων στην Κατάσταση των Επιφανειακών και Υπόγειων Υδάτων» που εκπονήθηκε από την ΠΑΝΑΓΙΩΤΑ ΣΤΥΛΙΑΝΗ ΚΑΪΜΑΚΗ στα πλαίσια της σύμβασης ΥΠ01/2014 και ειδικά οι αναφορές σε υδάτινα σώματα με σημαντικές πιέσεις (Πιν. 18-5).

xiv. Τον αριθμό των δειγμάτων που αναμένεται στατιστικώς να ληφθούν ετησίως από έναν σταθμό παρακολούθησης ανά τύπο ποταμού, με βάση την παρακολούθηση 2010-2014

xv. Τα σημεία xi-xiv πιο πάνω αποτελούν τη βάση για τη ριζική αναθεώρηση του προγράμματος παρακολούθησης των ποταμών που οδήγησε στο παρόν Πρωτόκολλο Συνεργασίας ΤΑΥ-ΓΧΚ 2015. Το παρόν Πρωτόκολλο Συνεργασίας, πέραν του 2015, δείχνει επίσης την προγραμματισμένη παρακολούθηση για την περίοδο 2015-2019 δηλ. μέχρι το τέλος του 3^{ου} κύκλου παρακολούθησης της ΟΠΥ.

2.2 Το Πρωτόκολλο Συνεργασίας περιλαμβάνει την παρακολούθηση των Επιφανειακών Υδάτων για εφαρμογή του Άρθρου 8 της Οδηγίας 2000/60/ΕΚ. Όσον αφορά τα Υπόγεια Ύδατα, από το 2015 όλες οι δειγματοληψίες υπόγειου νερού για εφαρμογή του Άρθρου 8 της ΟΠΥ αναλαμβάνονται από το Τμ. Γεωλογικής Επισκόπησης.

2.3 Αποτελείται από 5 Άρθρα (το κύριο μέρος) και 2 Παραρτήματα (Παράρτημα Α και Β), τα οποία είναι δεσμευτικά και αναπόσπαστο μέρος του.

2.4 Η διάρκεια του πρωτοκόλλου ακολουθεί την εφαρμογή του Προγράμματος Παρακολούθησης - Άρθρο 8 της ΟΠΥ. Ολοκληρώθηκαν ο 1^{ος} κύκλος (2007-2009) για το 1^{ο} ΣΔΛΑΠ καθώς και ο 2^{ος} κύκλος (2010 – Ιούλ. 2013) για το 2^{ο} ΣΔΛΑΠ. Το Σεπτ. 2013 άρχισε ο 3^{ος} κύκλος παρακολούθησης για τη συλλογή των απαιτούμενων δεδομένων για το 3^{ο} Σχέδιο Διαχείρισης Λεκανών Απορροής. Το πρωτόκολλο συνεργασίας μπορεί να επεκταθεί περαιτέρω με αμοιβαία συμφωνία των δύο συμβαλλόμενων μερών.

ΑΡΘΡΟ 3. ΠΕΔΙΟ ΣΥΝΕΡΓΑΣΙΑΣ

3.1 Δειγματοληψία και ανάλυση των ουσιών προτεραιότητας και λοιπών ουσιών που παρακολουθούνται στα εξής:

- Πρόγραμμα παρακολούθησης ποταμών
- Πρόγραμμα παρακολούθησης φυσικών λιμνών
- Πρόγραμμα παρακολούθησης ποτάμιων ταμιευτήρων νερού
- Πρόγραμμα παρακολούθησης υπόγειων υδάτων (κοινοποίηση των αποτελεσμάτων μόνο)

3.1.1 Ευθύνη δειγματοληψίας.

A. Το Τ.Α.Υ. είναι υπεύθυνο για την πραγματοποίηση της διαδικασίας δειγματοληψίας στους σταθμούς δειγματοληψίας (στους ποταμούς, φυσικές λίμνες, ποτάμιους ταμιευτήρες) που δίνονται στους πίνακες Α2, Α3 και Α4 του Παραρτήματος Α και για την παράδοση των δειγμάτων στο Γ.Χ.Κ. για την ανάλυσή τους.

B. Το Τ.Α.Υ. θα πραγματοποιήσει τη δειγματοληψία, τη διαδικασία προεργασίας (αν είναι απαραίτητο) και μεταφορά σύμφωνα με τα πρωτόκολλα και τις μεθόδους που παρουσιάζονται στον πίνακα Α8 του παραρτήματος Α.

C. Τα χρονοδιαγράμματα της δειγματοληψίας στους ποταμούς και στους ταμιευτήρες νερού παρουσιάζονται στον πίνακα Α1 του παραρτήματος Α. Όσον αφορά τους ποταμούς με εφήμερη/επεισοδιακή ροή (ephemeral/episodic rivers), είναι πιθανόν πως θα πρέπει να λαμβάνονται δείγματα και εκτός των περιόδων που δίδονται στον πίνακα Α1 για την συγκρότηση ενός ικανοποιητικού αριθμού δειγμάτων για τον προσδιορισμό της κατάστασης τους. Όσον αφορά τη λίμνη Παραλιμνίου δειγματοληψίες θα γίνονται μηνιαίως όταν η λίμνη έχει νερό (αλλά δεν δίδεται κανένα συγκεκριμένο χρονοδιάγραμμα). Αναμένονται πως θα ληφθούν 4 δείγματα ανά έτος σε χρονιές που η λίμνη έχει νερό. Οι δειγματοληψίες τόσο από τους ποταμούς με εφήμερη/επεισοδιακή ροή όσο από τη λίμνη Παραλιμνίου θα πραγματοποιούνται μετά από συνεννόηση του ΤΑΥ με το ΓΧΚ και ο συνολικός ετήσιος αριθμός δειγμάτων δεν θα υπερβεί τους αριθμούς που δίδονται στους πίνακες Α2 και Α4 αντίστοιχα.

D. Το Τ.Α.Υ. έχει ολόκληρη την ευθύνη για τις εκστρατείες δειγματοληψίας για τους ποταμούς, τις φυσικές λίμνες και τους ποτάμιους ταμιευτήρες νερού.

E. Για τα επιφανειακά ύδατα, το Γ.Χ.Κ. ενημερώνεται στις αρχές του έτους από το ΤΑΥ για το σχετικό χρονικό προγραμματισμό (βλ. πίνακα Α1 στο παράρτημα Α). Εβδομαδιαία προγράμματα με περισσότερη λεπτομέρεια (δειγματοληψίες ανά σημείο δειγματοληψίας και ανά μέρα) στέλνονται από το ΤΑΥ στο ΓΧΚ κατά την εβδομάδα πριν τις σχετικές δειγματοληψίες.

F. Το Γ.Χ.Κ. είναι αρμόδιο για την προετοιμασία του εξοπλισμού που απαιτείται για τη δειγματοληψία (φιάλες, κ.λπ.), όπως φαίνεται στον πίνακα Α8 του Παραρτήματος Α.

G. Το Τ.Α.Υ. είναι αρμόδιο για την κωδικοποίηση των σημείων (Location ID, sample ID & subsample ID) για να είναι δυνατή η μεταφορά των αποτελεσμάτων από την βάση δεδομένων LIMS του Γ.Χ.Κ. στη βάση CYMOS του Τ.Α.Υ. Το ΤΑΥ θα ενημερώνει το ΓΧΚ για τα subsample IDs της κάθε μηνιαίας εκστρατείας δειγματοληψιών το συντομότερο δυνατό μετά την ολοκλήρωση της κάθε εκστρατείας.

H. Το Γ.Χ.Κ. θα χρησιμοποιήσει τα Location ID του CYMOS και το ονόματα των σημείων δειγματοληψίας που του δίδει το ΤΑΥ για την επισήμανση όλων των αποτελεσμάτων, τόσο στις εκθέσεις σε hardcopy όσο και στο LIMS.

3.1.2 Ευθύνη ανάλυσης

A. Το Γ.Χ.Κ. είναι αρμόδιο για την ανάλυση των δειγμάτων για τις ουσίες προτεραιότητας και τις λοιπές ουσίες και την συμπλήρωση των αποτελεσμάτων στη σχετική βάση δεδομένων του προγράμματος παρακολούθησης.

B. Οι αναλύσεις θα γίνονται στα ακόλουθα διαπιστευμένα σύμφωνα με το ISO/IEC-17025 εργαστήρια του ΓΧΚ: Οι χημικές αναλύσεις στα εργ. 02, 06 και 10, οι μικροβιολογικές αναλύσεις στο εργ. 15 και η βιοπαρακολούθηση (χλωροφύλλη α και δοκιμές οικοτοξικότητας) στο εργ. 07 του ΓΧΚ.

C. Οι χημικές παράμετροι που πρέπει να αναλύονται παρουσιάζονται στον πίνακα Α8 του παραρτήματος Α για τους ποταμούς, τις φυσικές λίμνες και τους ποτάμιους ταμιευτήρες.

D. Οι πληροφορίες για τη διαδικασία ανάλυσης και τον κατάλληλο εξοπλισμό παρέχονται στον πίνακα Α9 του παραρτήματος Α.

E. Ο συνοψισμένος υπολογισμένος φόρτος εργασίας για το Γ.Χ.Κ. παρέχεται στον ακόλουθο πίνακα.

Πίνακας 1: Υπολογισμένος φόρτος εργασίας για το Γ.Χ.Κ

Κατηγορία Ύδατος	Εκτιμώμενος αριθμός δειγμάτων το 2015 *	
Ποτάμια	128	Επικίνδυνες και λοιπές ουσίες
	170	Μέταλλα, DOC
	292**	BOD/COD, Μικροβιολογία, Major ions, SiO_2
	126	TOC
	0	Ecotoxicology
Ποτάμιοι ταμιευτήρες νερού	48	Επικίνδυνες και λοιπές ουσίες
	52	Μέταλλα, DOC
	56	BOD/COD, Μικροβιολογία, Major ions, SiO_2
	48	Ecotoxicology
	45***	Chlorophyll a
	0	TOC
	39	2008/105/EC Art. 3.3 substances **in sediment (Metals, PAHs)**
Φυσικές λίμνες (Παραλίμνι, Ορόκλινη)	16	Επικίνδυνες και λοιπές ουσίες
	16	Μέταλλα, DOC
	16	BOD/COD, Μικροβιολογία, Major ions, SiO_2
	16	Chlorophyll a
	5	2008/105/EC Art. 3.3 substances **in sediment (Metals, PAHs)**

*) Ο πραγματικός αριθμός δειγμάτων εξαρτάται από την ύπαρξη ροής στα ποτάμια και από την προσβασιμότητα των ταμιευτήρων και παρουσιάζει σημαντικές μεταβολές από χρόνο σε χρόνο.
**) βλ. και Πιν. Α5 στο Παράρτημα Α
***) βλ. και Πιν. Α6 στο Παράρτημα Α

3.2 Δειγματοληψία και ανάλυση χλωροφύλλης α που παρακολουθείται στις λίμνες

3.2.1. Ευθύνη δειγματοληψίας

A. Το Τ.Α.Υ. είναι αρμόδιο για την πραγματοποίηση της διαδικασίας δειγματοληψίας στους σταθμούς δειγματοληψίας που δίνονται στον πίνακα Α3 και Α4 του παραρτήματος Α και την παράδοση τους στο Γ.Χ.Κ. για την ανάλυση. Οι πληροφορίες για τη μεθοδολογία δειγματοληψίας παρέχονται στον πίνακα Α6 του παραρτήματος Α.
B. Το σχετικό χρονικό πρόγραμμα των δειγματοληψιών παρουσιάζεται στους πίνακες Α3 και Α4 του παραρτήματος Α.
C. Το Τ.Α.Υ. έχει ολόκληρη την ευθύνη για τις εκστρατείες δειγματοληψίας.
D. Το Γ.Χ.Κ. πρέπει να ενημερώνεται από το Τ.Α.Υ. για το σχετικό χρονοδιάγραμμα δειγματοληψιών σύμφωνα με τα αναφερθέντα στο 3.1.1.Ε πιο πάνω.
E. Κατά τη δειγματοληψία η ομάδα δειγματοληψίας του ΤΑΥ συμπληρώνει το Έντυπο Δειγματοληψίας που παρουσιάζεται στο Παράρτημα Β. Κατά την παράδοση των δειγμάτων στο ΓΧΚ, ο παραλήπτης των δειγμάτων του ΓΧΚ υπογράφει στο Έντυπο την παραλαβή.

3.2.2. Ευθύνη ανάλυσης

A. Το Γ.Χ.Κ. και συγκεκριμένα το διαπιστευμένο εργαστήριο 07 είναι αρμόδιο για την ανάλυση των δειγμάτων για το φυτοπλαγκτόν (χλωροφύλλη α) και τη συμπλήρωση των αποτελεσμάτων στη σχετική βάση δεδομένων του προγράμματος παρακολούθησης.
B. Οι πληροφορίες για τη διαδικασία ανάλυσης και τον κατάλληλο εξοπλισμό παρέχονται στον πίνακα Α10 του παραρτήματος Α.

ΑΡΘΡΟ 4. ΑΠΟΤΕΛΕΣΜΑΤΑ ΚΑΙ ΑΞΙΟΛΟΓΗΣΗ

Ως μέγιστο χρόνο παράδοσης των εργαστηριακών εκθέσεων καθορίζεται το χρονικό διάστημα των δύο μηνών από την ημερομηνία παραλαβής των δειγμάτων. Τα αποτελέσματα των αναλύσεων παραδίδονται από το ΓΧΚ στο ΤΑΥ τόσο σε μορφή έκθεσης όσο και σε ψηφιακή μορφή κατάλληλη για εισαγωγή των αποτελεσμάτων, από το ΤΑΥ, στη βάση δεδομένων CYMOS.

Επιπλέον, τα αποτελέσματα όλων των δειγμάτων από υπόγεια νερά που λαμβάνονται από το Τμ. Γεωλογικής Επισκόπησης για εφαρμογή του Άρθρου 8 της ΟΠΥ αποστέλλονται και στο ΤΑΥ, τόσο σε μορφή έκθεσης όσο και σε ψηφιακή μορφή κατάλληλη για εισαγωγή στη βάση δεδομένων CYMOS.

Το ΓΧΚ θα αναγράφει στις εκθέσεις των αποτελεσμάτων και στους σχετικούς ψηφιακούς πίνακες, για το κάθε δείγμα:

1. τον κωδικό του σημείου δειγματοληψίας (όπως δίδονται στους πίνακες Α2, Α3 και Α4 στην στήλη «Cymos Station Code»)
2. το όνομα του σημείου δειγματοληψίας (σύμφωνα με τους πίνακες Α2, Α3, Α4)
3. την ημερομηνία δειγματοληψίας

Οι πιο πάνω πληροφορίες βρίσκονται και στο Έντυπο Δειγματοληψίας (βλ. Παράρτημα Β) του κάθε δείγματος, συμπληρωμένες από την εκάστοτε ομάδα δειγματοληψίας.

Κατά περιόδους - εφόσον τούτο κριθεί αναγκαίο – το Τμήμα Αναπτύξεως Υδάτων θα αξιολογεί τα αποτελέσματα και σε συνεργασία με το Γενικό Χημείο του Κράτους θα προβαίνουν σε αναπροσαρμογή του προγράμματος.

Το ΤΑΥ είναι αρμόδιο για την υποβολή των αποτελεσμάτων και γενικά για την ετοιμασία της σχετικής έκθεσης προς την Ευρωπαϊκή Ένωση, αντίγραφο της οποίας θα αποστέλλεται στο Γενικό Χημείο του Κράτους. Οι εκθέσεις και τα δεδομένα θα διατίθενται αμοιβαία σε ηλεκτρονική μορφή.

Σε κάθε έκθεση η επιστολή που ετοιμάζεται από το ΤΑΥ στην οποία παρατίθενται πρωτογενή ή επεξεργασμένα εργαστηριακά δεδομένα, να γίνεται σαφής αναφορά στο Εργαστήριο διεξαγωγής των αναλύσεων όπως π.χ. «οι αναλύσεις διεξήχθησαν στα διαπιστευμένα εργαστήρια του Γ.Χ.Κ.»

Τα αποτελέσματα θα μπορούν να αξιοποιούνται πολλαπλώς και από τα δύο Τμήματα.

Επίσης σε εκθέσεις, δημοσιεύσεις, παρουσιάσεις κ.α. θα γίνεται αναφορά και στα δύο συνεργαζόμενα Τμήματα ή και εργαστήρια.

ΆΡΘΡΟ 5. ΤΡΟΠΟΠΟΙΗΣΗ ΤΟΥ ΠΡΩΤΟΚΟΛΛΟΥ

Οποιαδήποτε τροποποίηση του πρωτοκόλλου με την αμοιβαία συμφωνία των δύο συμβαλλόμενων μερών πρέπει να καθοριστεί σε έγγραφη προσθήκη υπογεγραμμένη αμφότερα από τα συμβαλλόμενα μέρη.

(Δρ. Χαράλαμπος Δημητρίου)	(Μαρία Αλετράρη)
για Αν. Διευθυντή ΤΑΥ	για Διευθύντρια Γ.Χ.Κ.
Ημερομηνία: 22/9/15	Ημερομηνία: 29/9/15

Πίνακας Α2

Σημεία παρακολούθησης ποταμών 2015-2019: Κωδικοί, ονόματα, ομάδες ουσιών, συχνότητες

					VOCs, Org/chlorines&PCBs, Org/phos/ous, Triazines, Alachlor, PAHs					Org.Micropollutants & PAHs					Metals & DOC					Ecotoxicology					Major ions, SiO2, BOD/COD, Microbiology					TOC				
AA	Station_ID	Station name	Water body code	Assessment group	2015	2016	2017	2018	2019	2015	2016	2017	2018	2019	2015	2016	2017	2018	2019	2015	2016	2017	2018	2019	2015	2016	2017	2018	2019	2015	2016	2017	2018	2019
1	r1-1-1-75	Khapotami d/s Mandria (Yophyrin bridge)	CY_1-1-a_RP	P-important	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5	5	0	0	0	0	0	0	0
2	r1-1-3-95	Chapotami near Kissousa	CY_1-1-b_RI	I-important	6	6	0	0	0	2	2	0	0	0	6	6	0	0	0	0	0	0	0	0	7	7	0	0	0	7	0	0	0	0
3	r1-1-6-65	Chapotami near Kato Archimandrita	CY_1-1-c_RIh	Ih-minor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5	5	5	5	0	0	0	0	0
4	r1-2-1-96	Platys River u/s Dhiplopotamos locality	CY_1-2-b_RP	P-minor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5	0	0	0	0	0	0	0
5	r1-2-3-94	Phini River @ Pakhnoutis ford	CY_1-2-a_RP	P-minor	0	0	6	6	0	0	0	2	2	0	0	0	6	6	0	0	0	0	0	0	0	0	5	5	0	0	0	9	9	0
6	r1-2-6-64	Diarizos @ Ag. Georgios	CY_1-2-d_RI_HM	HMWB-Ih-important	0	0	0	6	6	0	0	0	2	2	0	0	0	6	6	0	0	0	0	0	0	0	0	5	5	0	0	0	0	0
7	r1-3-5-05	Xeros near Lazarides	CY_1-3-a_RP	P-negligible	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5	0	0	0	9	9	0	0	0
8	r1-3-6-53	Xeros @ Rotsos Ton Laoudion	CY_1-3-b_RI	I-minor	0	0	0	0	0	0	0	0	0	0	6	6	0	0	0	0	0	0	0	0	7	7	0	0	0	7	0	0	0	0
9	r1-3-8-60	Xeros near Foinikas	CY_1-3-c_RIh	Ih-minor	0	0	5	5	5	0	0	2	2	2	0	0	5	5	5	0	0	0	0	0	5	5	5	5	5	5	5	5	5	5
10	r1-4-1-98	Argaki Klimadhiou u/s Ayia Forest St.	CY_1-4-a_RP	P-negligible	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5	0	0	0	0	0	0	0	0
11	r1-4-3-35	Ayia u/s Kannaviou Reservoir	CY_1-4-b_RI	I-negligible	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	7	0	0	0	7	7	0	0	0
12	r1-4-6-75	Varkas River near Amargeti	CY_1-4-k_RIh	Ih-important	5	5	5	0	0	2	2	2	0	0	5	5	5	0	0	0	0	0	0	0	5	5	5	5	5	0	0	0	0	0
13	r1-4-7-10	Ezousas near Moro Nero	CY_1-4-f_RP_HM	HMWB-P-minor	0	0	0	6	6	0	0	0	2	2	0	0	0	6	6	0	0	0	0	0	0	0	0	5	5	0	0	0	0	0
14	r1-4-8-88	Kochatis River near Koloni	CY_1-4-m_RIh	Ih-important	5	5	5	0	0	2	2	2	0	0	5	5	5	0	0	0	0	0	0	0	5	5	5	5	5	0	5	5	5	5
15	r1-4-9-80	Ezousa near Akhelia	CY_1-4-h_RIh_HM	HMWB-E-minor	3	3	3	3	3	2	2	2	2	2	3	3	3	3	3	0	0	0	0	0	3	3	3	3	3	0	0	0	0	0
16	r1-5-5-89	Koshinas River near Kaliadhes locality	CY_1-5-d_RE_HM	HMWB-E-minor	3	3	3	3	3	2	2	2	2	2	3	3	3	3	3	0	0	0	0	0	3	3	3	3	3	0	0	0	0	0
17	r1-6-2-17	Mavrokolympos R.@ Krya Vrysi	CY_1-6-a_RIh	Ih-minor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5	5	5	5	5	5	5	5	5
18	r1-8-5-89	Pevkos R. @ Lara Road	CY_1-8-b_RIh	Ih-minor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5	5	5	5	5	0	0	0	0
19	r2-1-8-74	Argaki tou Ayiou Ioanni near Skopeftirio	CY_2-1-a_RE	E-important	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	3	3	3	0	0	0	0	0
20	r2-2-3-95	Chrysochou near Skoulli	CY_2-2-b_RI	I-important	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	7	0	0	0	7	7
21	r2-2-6-35	Stavros tis Psokas near Sarama quarry	CY_2-2-d_RI	I-important	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	7	7	0	0	0	0	0	0	0
22	r2-3-1-64	Mirmikoph River d/s Steni	CY_2-3-a_RIh	Ih-important	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5	5	5	5	0	0	0	0	0
23	r2-3-2-96	Pelathousa R. (Argaki tis Limnis) @ Polis-Argaka	CY_2-3-b_RIh	Ih-important	0	5	5	5	0	0	2	2	2	0	5	5	5	5	5	0	0	0	0	0	5	5	5	5	5	0	0	0	0	0
24	r2-3-4-80	Makounta U/S Argaka Dam	CY_2-3-c_RI	I-minor	0	0	0	0	0	0	0	0	0	0	0	0	0	6	6	0	0	0	0	0	0	0	0	7	7	0	0	0	0	0
25	r2-3-7-74	Xeropotamos d/s Poros tou Sykarkou	CY_2-3-e_RE	E-negligible	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	3	3	3	0	0	0	0	0
26	r2-3-8-48	Gialia @ Pochalandra	CY_2-3-f_RP	P-negligible	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5	0	0	0	0	0	0
27	r2-4-6-70	Leivadi u/s Pomos resevoir	CY_2-4-d_RI	I-negligible	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	7	0	0	0	7	7	0	0
28	r2-6-1-92	Katouris u/s Pyrgos reservoir	CY_2-6-a_RIh	Ih-negligible	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5	5	5	5	5	5	5	5	5
29	r2-7-2-75	Pyrgos near Fleva	CY_2-7-a_RI	I-minor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	7	0	0	0	7	7	0
30	r2-8-3-10	Limnitis Saw Mill	CY_2-8-a_RP	P-negligible	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5	0	0	0	9	9
31	r2-9-2-50	Kambos R. Near Ag. Varvara	CY_2-9-b_RP	P-minor	0	0	6	6	0	0	0	2	2	0	0	0	6	6	0	0	0	0	0	0	0	0	5	5	0	0	0	0	0	0
32	r3-1-2-30	Xeros R. U/S Kafizes Dam	CY_3-1-b_RI	I-negligible	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	7	0	0	0	7	7	0
33	r3-2-1-85	Marathasa U/S Kalopanagiotis Dam	CY_3-2-a_RP	P-minor	0	6	6	0	0	0	2	2	0	0	0	6	6	0	0	0	0	0	0	0	0	5	5	0	0	0	9	9	0	0
34	r3-2-3-48	Vrountokremni Argakin u/s Yeronta locality	CY_3-2-e_RE	E-negligible	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	3	3	3	0	0	0	0	0
35	r3-3-1-60	Agios Nikolaos U/S Fish Farm	CY_3-3-a_RP	P-negligible	0	0	0	0	0	0	0	0	0	0	6	6	0	0	0	0	0	0	0	0	5	5	0	0	0	9	9	0	0	0
36	r3-3-2-60	Argaki tou Karvouna @ Platania	CY_3-3-d_RP	P-important	0	0	0	0	0	0	0	0	0	0	6	6	0	0	0	0	0	0	0	0	5	5	0	0	0	9	0	0	0	0
37	r3-3-3-95	Kargotis near Evrychou	CY_3-3-b_RP	P-important	0	0	0	6	6	0	0	0	2	2	0	0	0	6	6	0	0	0	0	0	0	0	0	5	5	0	0	0	9	9
38	r3-4-2-90	Atsas near Evrychou	CY_3-4-b_RIh	Ih-important	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5	5	5	5	0	0	0	0	0
39	r3-5-1-50	Lagoudera near Lagoudera Br.	CY_3-5-a_RI	I-minor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	7	0	0	0	7	7
40	r3-5-4-40	Elia near Vyzakia	CY_3-5-c_RI_HM	HMWB-Ih-minor	6	6	0	0	0	2	2	0	0	0	5	5	5	5	5	0	0	0	0	0	5	5	Hardn	Hardn	Hardn	0	0	0	0	0
41	r3-6-2-53	Potami near Astromeritis	CY_3-6-b_RE	E-minor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	3	3	3	0	0	0	0	0
42	r3-6-3-59	Komitis R. d/s Astromeritis	CY_3-6-c_RE	E-important	3	3	3	3	3	2	2	2	2	2	3	3	3	3	3	0	0	0	0	0	3	3	3	3	3	0	0	0	0	0
43	r3-7-1-55	Peristerona R. @ Siphilos	CY_3-7-a_RI	I-minor	6	6	0	0	0	2	2	0	0	0	6	6	0	0	0	0	0	0	0	0	7	7	0	0	0	7	7	0	0	0
44	r3-7-1-84	Peristerona @ Peristerona	CY_3-7-c_RE	E-minor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	3	3	3	0	0	0	0	0
45	r3-7-3-71	Akaki U/S Akaki-Malounta Dam	CY_3-7-f_RI_HM	HMWB-I-minor	0	0	0	6	6	0	0	0	2	2	0	0	0	6	6	0	0	0	0	0	0	0	0	7	7	0	0	0	7	7
46	r3-7-5-35	Aloupos R. near Arediou	CY_3-7-n_RIh	Ih-minor	5	5	0	0	5	2	2	0	0	2	5	5	0	0	5	0	0	0	0	0	5	5	5	5	5	0	0	0	0	0
47	r3-7-5-50	Koutis R. @ Asprokremnos locality	CY_3-7-o_RE	E-minor	3	3	3	3	3	2	2	2	2	2	3	3	3	3	3	0	0	0	0	0	3	3	3	3	3	0	0	0	0	0
48	r6-1-1-72	Pediaios R. @ Philani	CY_6-1-a_RIh	Ih-minor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5	5	5	5	0	5	5	5	5
49	r6-1-2-38	Pediaios near Kato Deftera	CY_6-1-d_RE_HM	HMWB-E-minor	3	3	3	3	3	2	2	2	2	2	3	3	3	3	3	0	0	0	0	0	3	3	3	3	3	0	0	0	0	0
50	r6-1-2-90	Pediaios near Lefkosia	CY_6-1-e_RE_HM	HMWB-E-important	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	3	3	3	0	0	0	0	0
51	r6-1-5-52	Vathys @ Athalassa Park	CY_6-1-L_RE	E-important	3	3	3	3	3	2	2	2	2	2	3	3	3	3	3	0	0	0	0	0	3	3	3	3	3	0	0	0	0	0
52	r6-5-1-34	Yialias River near Azizis locality (Lythrodontas)	CY_6-5-a_RIh	Ih-minor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5	5	5	5	5	0	5	0	5
53	r6-5-1-85	Gialias near Kotsiati	CY_6-5-b_RI	I-important	6	0	0	0	6	2	0	0	0	2	6	0	0	0	6	0	0	0	0	0	7	0	0	0	7	7	0	0	0	0
54	r6-5-2-45	Alykos R. near Margi	CY_6-5-h_RE	E-important	3	3	3	3	3	2	2	2	2	2	3	3	3	3	3	0	0	0	0	0	3	3	3	3	3	0	0	0	0	0
55	r6-5-2-50	Almyros R. @ Tseri-Margi Road	CY_6-5-i_RE	E-minor	3	3	3	3	3	2	2	2	2	2	3	3	3	3	3	0	0	0	0	0	3	3	3	3	3	0	0	0	0	0
56	r6-5-2-85	Alykos d/s Dhali Industrial Area	CY_6-5-h_RE	E-important	3	3	3	3	3	2	2	2	2	2	3	3	3	3	3	0	0	0	0	0	3	3	3	3	3	0	0	0	0	0
57	r6-5-3-15	Gialias near Nisou	CY_6-5-c_RE	E-important	3	3	3	3	3	2	2	2	2	2	3	3	3	3	3	0	0	0	0	0	3	3	3	3	3	0	0	0	0	0
58	r6-5-3-50	Gialias near Potamia	CY_6-5-c_RE	E-important	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	3	3	3	0	0	0	0	0
59	r8-2-4-10	Aradippou @ Aradippou	CY_8-2-a_RE	E-important	3	3	3	3	3	2	2	2	2	2	3	3	3	3	3	0	0	0	0	0	3	3	3	3	3	0	0	0	0	0
60	r8-3-2-60	Kalo Chorio R. @ Kamares	CY_8-3-a_RE	E-minor	3	3	3	3	3	2	2	2	2	2	3	3	3	3	3	0	0	0	0	0	3	3	3	3	3	0	0	0	0	0

Πίνακας A2 (Συνέχεια)

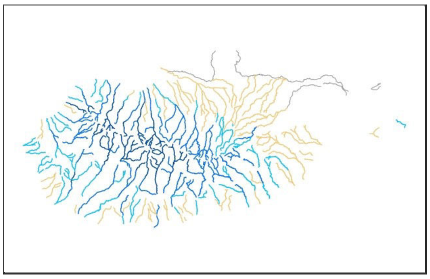
					VOCs, Org/chlorines&PCBs, Org/phos/ous, Triazines, Alachlor, PAHs					Org.Micropollutants & PAHs					Metals & DOC					Ecotoxicology					Major ions, SiO2, BOD/COD, Microbiology					TOC				
AA	Station_ID	Station name	Water body code	Assessment group	2015	2016	2017	2018	2019	2015	2016	2017	2018	2019	2015	2016	2017	2018	2019	2015	2016	2017	2018	2019	2015	2016	2017	2018	2019	2015	2016	2017	2018	2019
61	r8-4-1-58	Xylias u/s Lympia reservoir	CY_8-4-b_RE	E-minor	0	0	0	0	0	0	0	0	0	0	3	3	3	3	3	0	0	0	0	0	3	3	3	3	3	0	0	0	0	0
62	r8-4-3-40	Treminthos near Agia Anna	CY_8-4-c_RE_HM	HMWB-E-important	3	3	3	3	3	2	2	2	2	2	3	3	3	3	3	0	0	0	0	0	3	3	3	3	3	0	0	0	0	0
63	r8-4-4-72	Ayios Ioannis R. near Stazousa	CY_8-4-g_RE	E-minor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	3	3	3	0	0	0	0	0
64	r8-5-1-60	Pouzis River near Alethriko	CY_8-5-a_RIh	Ih-minor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5	5	5	5	0	0	5	0	5
65	r8-6-3-50	Xeropotamos near Alaminos	CY_8-6-a_RIh	Ih-important	5	0	0	5	5	2	0	0	2	2	5	0	0	5	5	0	0	0	0	0	5	5	5	5	5	0	0	0	0	0
66	r8-7-1-65	Syriatis R. @ Kyprovasa	CY_8-7-a_RI	I-minor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	7	0	0	0	0	0	0	0
67	r8-7-2-60	Syriatis near Pano Lefkara	CY_8-7-c_RI_HM	HMWB-Ih-important	5	0	0	0	5	2	0	0	0	2	5	0	0	0	5	0	0	0	0	0	5	0	0	0	5	0	0	0	0	0
68	r8-7-3-95	Argaki tou Mylou u/s Dhypotamos reservoir	CY_8-7-d_RIh	Ih-minor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5	5	5	5	0	0	5	0	5
69	r8-8-2-95	Maroni near Choirokoitia	CY_8-8-c_RIh_HM	HMWB-Ih-minor	0	5	5	5	0	0	2	2	2	0	0	5	5	5	0	0	0	0	0	0	0	5	5	5	0	0	0	0	0	0
70	r8-9-3-83	Exovounia River near Layia	CY_8-9-g_RIh	Ih-important	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5	5	5	5	0	0	0	0	0
71	r8-9-5-40	Vasilikos near Lageia	CY_8-9-c_RI	I-important	6	6	0	0	0	2	2	0	0	0	6	6	0	0	0	0	0	0	0	0	7	7	0	0	0	7	7	0	0	0
72	r8-9-6-98	Argaki Asgatas near Kalavasos	CY_8-9-h_RIh	Ih-minor	0	0	0	0	0	0	0	0	0	0	5	0	0	5	5	0	0	0	0	0	5	5	5	5	5	0	5	5	5	5
73	r9-1-3-80	Argaki tis Monis near Moni	CY_9-1-e_RE	E-important	3	3	3	3	3	2	2	2	2	2	3	3	3	3	3	0	0	0	0	0	3	3	3	3	3	0	0	0	0	0
74	r9-1-4-51	Argaki tou Pyrgou u/s recharge dam	CY_9-1-b_RIh	Ih-important	5	5	0	0	5	2	2	0	0	2	5	5	0	0	5	0	0	0	0	0	5	5	5	5	5	0	5	5	5	5
75	r9-2-1-43	Ayios Pavlos River u/s Kalimera diversion	CY_9-2-b_RP	P-important	0	6	6	6	0	0	2	2	2	0	0	6	6	6	0	0	0	0	0	0	0	5	5	5	0	0	0	0	0	0
76	r9-2-3-05	Germasogeia R. @ Dierona	CY_9-2-e_RI	I-important	6	6	0	0	0	2	2	0	0	0	6	6	0	0	0	0	0	0	0	0	7	7	0	0	0	7	7	0	0	0
77	r9-2-3-85	Germasogeia near Foinikaria	CY_9-2-f_RI	I-minor	0	0	0	0	0	0	0	0	0	0	0	0	6	6	0	0	0	0	0	0	0	0	7	7	0	0	0	7	7	0
78	r9-2-4-27	Argaki tou Monastiriou near Amyrou Monastery	CY_9-2-j_RI	I-negligible	0	0	0	0	0	0	0	0	0	0	0	0	0	6	6	0	0	0	0	0	0	0	0	7	7	0	0	0	0	0
79	r9-2-4-95	Gialiades (Akrounta) U/S Germasogeia Dam	CY_9-2-L_RI_HM	HMWB-I-important	6	6	0	0	0	2	2	0	0	0	6	6	0	0	0	0	0	0	0	0	7	7	0	0	0	0	0	0	0	0
80	r9-4-3-39	Phasoula d/s Paramytha	CY_9-4-g_RIh	Ih-important	5	5	5	0	0	2	2	2	0	0	5	5	5	0	0	0	0	0	0	0	5	5	5	5	5	0	0	0	0	0
81	r9-4-3-41	Garyllis R. @ Paramytha	CY_9-4-b_RI	I-minor	0	0	0	6	6	0	0	0	2	2	0	0	0	6	6	0	0	0	3	3	0	0	0	7	7	0	0	0	0	0
82	r9-4-3-80	Garyllis U/S Polemidia Dam	CY_9-4-c_RI	I-important	0	0	0	6	6	0	0	0	2	2	6	6	6	6	6	0	0	0	3	3	Hardn	Hardn	Hardn	7	7	0	0	0	7	7
83	r9-5-1-99	Ypsonas near Ypsonas	CY_9-5-a_RE	E-minor	3	3	3	3	3	2	2	2	2	2	3	3	3	3	3	0	0	0	0	0	3	3	3	3	3	0	0	0	0	0
84	r9-6-1-44	Kryos R. U/S Myllomeris Waterfall	CY_9-6-p_RP	P-minor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5	0	0	0	9	9	0	0	0
85	r9-6-1-87	Kryos @ Koilani	CY_9-6-q_RP_HM	HMWB-P-minor	0	0	0	6	6	0	0	0	2	2	0	0	0	6	6	0	0	0	0	0	0	0	0	5	5	0	0	0	0	0
86	r9-6-2-60	Kryos U/S Tunnel Outlet	CY_9-6-r_RI_HM	HMWB-Ih-minor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5	5	0	0	0	0	0
87	r9-6-3-36	Kouris near Kato Amiantos	CY_9-6-L_RP	P-important	0	0	0	6	6	0	0	0	2	2	6	6	6	6	6	0	0	0	0	0	Hardn	Hardn	Hardn	5	5	0	0	0	9	9
88	r9-6-3-77	Mesapotamos u/s Saittas diversion	CY_9-6-n_RP	P-negligible	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5	0	0	0	9	9	0	0
89	r9-6-3-87	Moniatis River @ Lourka locality	CY_9-6-o_RP	P-important	0	0	6	6	0	0	0	2	2	0	0	0	6	6	0	0	0	0	0	0	0	0	5	5	5	0	0	0	0	0
90	r9-6-4-92	Kouris @ Alassa New Weir	CY_9-6-m_RP_HM	HMWB-P-important	0	6	6	0	0	0	2	2	0	0	0	6	6	0	0	0	0	0	0	0	0	5	5	0	0	0	9	9	0	0
91	r9-6-5-62	Agros River Near Ag. Ioannis	CY_9-6-b_RP	P-important	0	0	6	6	6	0	0	2	2	2	0	0	6	6	6	0	0	0	0	0	0	0	5	5	5	0	0	0	0	0
92	r9-6-5-63	Ambelikos River d/s Potamitissa	CY_9-6-b_RP	P-important	6	6	6	0	0	2	2	2	0	0	6	6	6	0	0	0	0	0	0	0	5	5	5	0	0	0	0	0	0	0
93	r9-6-6-32	Limnatis R. Near Ag. Mamas	CY_9-6-e_RP	P-important	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	5	9	0	0	0	9
94	r9-6-7-70	Limnatis (Zygos) U/S Kouris Dam	CY_9-6-f_RI	I-important	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	7	7	0	0	0	0
				year	2015	2016	2017	2018	2019	2015	2016	2017	2018	2019	2015	2016	2017	2018	2019	2015	2016	2017	2018	2019	2015	2016	2017	2018	2019	2015	2016	2017	2018	2019
				# of samples	128	140	123	143	130	60	64	58	64	60	170	172	149	174	160	0	0	0	6	6	292	312	284	312	290	126	124	114	120	114
				Comparison with 2014 # of samples	89%	97%	85%	99%	90%						98%	99%	86%	100%	92%						94%	100%	91%	100%	93%	81%	79%	73%	77%	73%

Appendix 20 Metadata of the river water body network

The metadata of the river water body network elaborated by this study (cf. chapters 3.1.5 and 4.1.4) is given below (3 pages):

Updated river water bodies for the 2nd Cyprus River Basin Management Plan (Implementation of Directive 2000/60/EC)

SDE Feature Class



Tags

River, Water body, Water Framework Directive, Mediterranean rivers

Summary

These river water bodies are the result of the review and update of Article 5 of Directive 2000/60/EC as far as the Cyprus river water bodies are concerned.

Description

Attribute fields:

river_name: name of the stream or river reach. names were taken from various maps (K717 "Military map" 50k topo map; 25k topo map; 5k 1970 topo map; Land Registry Office (LRO) cadastral maps, mainly 1:5000). Where a water body consists of two equally "important" tributaries, both names are given separated by a "&"

Occupied: Indication whether a water body is located in the occupied part of Cyprus or not. Only water bodies that are completely in the occupied part are indicated by "YES".

HMWB: indication whether a water body is heavily modified or not, and whether it was a HMWB in the 2005 water body network already (YES2005) or if it is provisionally designated by this study (YES_Prop)

Riv_type: the river type of the stream of river reach. The types correspond to the TSRP (Temporary stream regime plot) river types proposed by Gallart et al. (2012) and Prat et al. (submitted) and were determined using the Mf-Sd6 indexes proposed for this purpose by the aforementioned authors.

Gallart, F. et al. (2012). A novel approach to analysing the regimes of temporary streams in relation to their controls on the composition and structure of aquatic biota. Hydrology and Earth System Sciences, 16(9), pp.3165–3182.

Prat, N. et al. (submitted). The mirage toolbox: an integrated assessment tool for temporary streams. River Research and Applications.

Assmnt_grp: the assessment group of each stream / river reach. The water bodies in each group have comparable pressure situations and thus the status of water bodies without monitoring data may be assessed from water bodies with monitoring data in the same group. Pressure that were considered for the establishment of the groups are urbanization (proxy: population density of the water body's catchment, source data: CyStat 2011 Census), agriculture (proxy: % of water body catchment area occupied by "intense agriculture", source data: Corine 2006), livestock (proxy: Annual N-load from livestock units in buffers around the water bodies, source data: livestock units incl. animal numbers 2012&2013 from Cyprus Veterinary Servies and N-load figures from DEFRA, 2009). The boundary between the "minor" and "important" groups correspond approximately the boundary between good and moderate ecological status.

DEFRA. (2009). Guidance for Farmers in Nitrate Vulnerable Zones. Standard values, manure sampling protocol and glossary. London: Department for Environment, Food and Rural Affairs.

Catchmt_nm: the name of the catchment, based on the historic Cyprus river catchments

MS_CD: the code of the catchment, based on the historic Cyprus river catchments

Length_km: the length of the stream / river reach

rv_sub_tp: the river sub-type. sub types were assigned:

under the P type, a spring fed perennial type Ps and a type with low invertebrate species diversity Plwdv (after project TAY26/2010 results) was assigned

under the E type, a "coastal lowland" type Ecl was assigned; this represents streams that are assumed to have largely episodic flow regimes.

The sub types are not intended to be used for assessment of status.

WBcd_2013: the code of the stream / river reach

WB_cd_2005:the code of the corresponding water body in the WFD river water body network of 2005 (WL | Delft Hydraulics, ENVECO S.A. and D. Argyropoulos & associates. (2004). Volume 1. Characterisation of surface water body types.)

WBcd13old: WB codes as they were assigned before taking into accout also the impounded rivers for the coding. For future reference.

WBcd13ini: WB codes that were used throughout the whole Art. 5 river water body review study, before commissioning the final format of WB codes. This will be very useful for future reference to relate WBs back to older stages of the study where all WBs had been referenced with these codes. Nevertheless, they are not fully valid back to the very start of the study as these codes have changed due to WB merging, splitting, etc.as the study was going on.

wb_nm_short_en: WB short name in English (2015). These names were found from the "Gazetteer of Cyprus" of 1987.

wb_nm_short_gr: WB short name in Greek (2015). These names were found from the "Gazetteer of Cyprus" of 1987.

Credits

Gerald Dörflinger (Hydrologist, Water Development Department, Cyprus)

Use limitations

This dataset may be used only after being provided directly to the user by the Water Development Department and if proper reference is made to the dataset and its source in any publication, product or other outcome from the use of the dataset.

Extent

West	32.311835	**East**	34.022692
North	35.294182	**South**	34.641830

Scale Range

Maximum (zoomed in)	1:5,000
Minimum (zoomed out)	1:150,000,000

You are currently using the Item Description metadata style. Change your metadata style in the Options dialog box to see additional metadata content.

Supplement: Map of revised WFD water bodies with water body codes and names